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ABSTRACT

This is a report on a two-day conference, held at the University of Maryland in August of 1974, to examine the impact of the National Science Foundation (NSF) on science curriculum development in the United States. The conference covered the improvement of science teaching materials and instruction development as well as the overall considerations. This report consists of six sections: (1) Introduction, which presents the purpose of the conference; (2) Procedures Used, which include conference participants, conference schedule, and conference location; (3) Results of the Conference, which include four papers and possible studies; (4) Recommendations to the NSF; (5) Selected Bibliography; and (6) Appendices, which include participants' journal articles. The four papers presented in section three discuss the impact of existing programs, thoughts on impact, examples of change, and possible areas of impact. (HM)

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A REPORT ON THE
EXPLORATORY CONFERENCE ON THE NATIONAL SCIENCE FOUNDATION'S
IMPACT ON U. S. SCIENCE CURRICULUM DEVELOPMENT

Held at the Science Teaching Center and the
Center of Adult Education, University of Maryland
College Park on August 8, 9, 1974

This Report Compiled and Edited
on behalf of the Conference Participants by
the Conference Director,
J. David Lockard

Submitted to the
National Science Foundation
August, 1975

SE 029 451

A Report on the
Exploratory Conference on the National Science Foundation's
Impact on U.S. Science Curriculum Development

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A REPORT ON THE
EXPLORATORY CONFERENCE ON THE NATIONAL SCIENCE FOUNDATION'S
IMPACT ON U.S. SCIENCE CURRICULUM DEVELOPMENT

- Maryland Impact Conference -

Introduction

Since its beginnings in 1950, the National Science Foundation has had as a part of its mission the improvement of science teaching in the United States. This has included a number of facets such as: the training of scientists for both research and teaching; the updating and retraining of elementary and secondary science and mathematics teachers; the dissemination of science and science-related information; the furnishing of funds for expanding instructional services and facilities; the graduate training of science supervisors; and the development and implementation of science and mathematics curricular developments at all levels. A large amount of time and money have been utilized in these important activities. One of the more beneficial endeavors has been in the various fields of science and mathematics curricular development. It has appropriately and cooperatively involved a large number of scientists, science educators, educational psychologists and classroom teachers from every facet of education.

With all this involvement of time and money there arises the basic question, what has been the impact of the National Science Foundation's activities of science education in the United States, and to a specific point, on science curriculum development across the country? Familiar to many persons are the "alphabet soup" projects in the United States that have been directly or indirectly funded by the National Science Foundation. In addition, many adaptations and translations of these materials have appeared throughout the world. The question of what effect the earliest NSF endeavors had on science and mathematics curricular development in other countries and thus the impact on science education improvement

world-wide can also be raised. What kinds of spin-off programs have resulted? How have children, youth and adults been affected by these projects? How has the quality of classroom instruction been affected? How have other organizations and institutions responded and modified their programs due to the NSF's work? What has been the total financial investment in science education improvement due to the seed money first invested by the National Science Foundation? How is the image of the United States in the eyes of our fellow nations been changed by the National Science Foundation's interest in education? How has the development of new materials and facilities affected the science equipment and laboratory facilities of educational institutions of America because of the NSF's interest? The questions are unending but the one crucial question still remains. While all of the above questions and many others need to be studied, the major concern is still: how is the science learning by boys and girls and men and women been improved?

Although this kind of evaluative questioning has been badly neglected over the years, it is now crucial in these times of tight budgets and changing priorities that the National Science Foundation encourage and support appropriate studies of its effects and its impact on science education improvement.

I. PURPOSE OF THE CONFERENCE

To help design some possible guidelines for such studies a two-day conference was held at the University of Maryland in August of 1974 that had as its major objective the stimulation of constructive ideas on the kinds of studies that could best evaluate the impact the National Science Foundation has had on science curriculum development in the United States. It covered the improvement of science teaching materials and instruction development as well as the overall considerations.

II. PROCEDURES USED

Since the conference was an intense interaction working session a small but highly qualified group were selected as outstanding representatives of their professional colleagues taking into consideration: geographic distribution; educational grade level; type of professional employment; academic speciality; science background field; and philosophical positions.

- Conference Convenor and Chairman:

J. David Lockard - Director of the University of Maryland's Science Teaching Center and of the NSF-sponsored International Clearinghouse on Science and Mathematics Curricular Developments, Joint appointee as a plant physiologist in the Botany Department, President of the International Council of Associations of Science Education (ICASE); formerly high school science teacher, department chairman, science supervisor, and President of the National Association for Research in Science Teaching (NARST).

- Participants:

Robert W. Howe - Director of the NIE-sponsored ERIC Information Analysis Center for Science, Mathematics and Environmental Education and Professor and Chairman, Faculty of Science and Mathematics Education, the Ohio State University; formerly science teacher, administrator and researcher and Coordinator for the National Association for Research in Science Teaching.

Paul DeHart Hurd - Professor Emeritus of Education, Stanford University, Chairman, Advisory Committee on the BSCS Human Sciences Curriculum Project, Member Advisory Committees for the Educational Research Council of America and the University of Pittsburgh Individualized Science Project, and consultant to the National Aeronautics and Space Administration; formerly Professor of Science Education, Stanford University, high school and junior college biology teacher and department chairman, science author and President of NARST.

Alice J. Moses - Elementary science teacher, University of Chicago Laboratory Schools and Summer School Principal of the Nursery through High School program and member, Board of Directors of the National Science Teachers Association; formerly teacher and coordinator of Science and Social Studies, Fullbright Exchange Teacher to Oxford, England, and Member Board of Directors of the Council on Elementary Science International.

Lester G. Paldy - Director of the Science and Mathematics Teaching Center at the State University of New York at Stony Brook and member of the Physics faculty, co-editor of national and legislative news for the Journal of College Science Teaching, consulting editor of The Physics Teacher, staff physicist for the American Association of Physics Teachers, and member of the Advisory Board of Physics Today.

Ronald D. Townsend - Science Curriculum Supervisor, Evanston Township, Illinois, High School, curriculum project implementor, science film developer and science text author; formerly member Science Education faculty, University of Iowa, educational consultant to the National Science Lisé Project in Ankara, Turkey, and high school science and mathematics teacher, SSMA Director.

James R. Wailes - Professor of Science Education, University of Colorado, Director of Institutes for science teachers and supervisors and assistant director of the Pre-Service Teacher Education Program; formerly member, Executive Committee of the National Science Teachers Association, Chairman of the Division of Elementary Education at University of Colorado, educational consultant, implementor and author, NSTA evaluator of the impact of the National Assessment of Educational Progress.

Wayne W. Welch - Director of the Minnesota Research and Evaluation Project and Professor, Educational Psychology, College of Education, University of Minnesota; formerly high school physics and mathematics teacher and department chairman, evaluator for Harvard Project Physics and other curriculum projects, Consultant to U.S.O.E., NSF and Ford Foundation, and President of NARST.

The Conference Schedule
Center of Adult Education
University of Maryland

Wednesday Evening - August 7, 1974

8:00 PM - Informal Social Hour and Visit to The International Clearinghouse
Collection in the University's Science Teaching Center

Thursday - August 8, 1974

7:00-8:30 AM Breakfast

8:30-9:00 AM Registration and Distribution of Discussion Papers

9:00-9:30 AM Opening Session - David Lockard, Chairman
Purpose of the Conference
Introduction of Participants
Conference Challenge Comments - Howard Hausman

9:30 AM Presentations on Review of Past and On-Going Studies of the
Impact of NSF
"Impact of NSF-sponsored Programs on Elementary and
Secondary School Programs, Teachers and Students" by
Robert W. Howe, Director ERIC/SMEAC, Ohio State University
"Some Thoughts on the Impact of National Curriculum
Projects" by
Wayne W. Welch, Assistant Dean, College of Education,
University of Minnesota

10:45 AM Coffee Break

11:00 AM Group Discussion of Prior and On-Going Impact Studies

12:15 Lunch

1:30 PM Identification of Area Matrices Deserving Investigation
A. Already Completed
B. In Progress
C. Remaining Gaps

3:30 PM Coffee Break

3:45 PM Priorities Deserving Investigation

5:15 PM Sub-Group Task Assignments

5:30 PM Break Time

6:30 PM Dinner

8:00-10:00 PM Sub-Group Task Meetings

(Secretaries duplicated Task Group Reports for evening study)

Friday - August 9, 1974

7:30 AM	Breakfast
9:00 AM	Sub-Group Task Reports and Group Discussion
	1. Studies on Changes in Institutions and Programs - Paul Hurd and Lester Paldy
	2. Studies on Learning - Alice Moses and Ronald Townsend
	3. Studies on Use - Robert Howe and James Wailes
	4. Studies on Personnel Affected, Evaluation Strategies, and Dissemination Plans - David Lockard and Wayne Welch
10:30 AM	Coffee Break and Re-writing
11:00 AM	Second Sub-Group Task Meeting (worked through with lunch at session)
2:00 PM	Second Sub-Group Report Session
3:30 PM	Discussion of Sub-Group Report
4:30 PM	Discussion of Final Publication Outline and Specific Contents Including Recommendations
5:00 PM	Close of Conference

The Conference Location:

The "Impact Conference" was held at the University of Maryland Science Teaching Center and the Center of Adult Education. This allowed for conference rooms, housing, and meals as well as access to the NSF-supported International Clearinghouse archives collection of science and mathematics curriculum materials. The University is eight miles from downtown Washington with ready access to the three area airports and a short drive for NSF staff observers in the Washington offices who were observers at the conference.

III. RESULTS OF THE CONFERENCE

A. Background and Working Papers

With such a short period for a working conference it was felt that some background information should be furnished the participants to trigger early discussions. The first two papers that follow were extensive ones used as conference keynote addresses while the other two were outlines to stimulate possible reactions. Copies of the background and working papers follow.

1. IMPACT OF NSF SPONSORED PROGRAMS ON ELEMENTARY AND SECONDARY SCHOOL PROGRAMS; TEACHERS AND STUDENTS

by Robert W. Howe, Director ERIC/SMEAC

Introduction

This report includes analyses of research studies and written reports that present information on: (1) use of NSF sponsored and other materials; (2) variables related to the use of NSF sponsored materials; (3) impact of the use of NSF materials on teaching style and learning; and (4) impact of inservice education on use of NSF materials and teacher behavior. A summary and a discussion conclude the report. A selective bibliography of related material is appended. Some of the items listed in the bibliography are cited, though many are not; they are listed for reference purposes and for further use in the conference. The report and the bibliography focus on research completed since 1967.

The Center for Science and Mathematics Education at The Ohio State University, The ERIC Center for Science, Mathematics, and Environmental Education, and selected consultants have been involved in a number of studies, both surveys and literature reviews related to the above topics. Studies conducted under the auspices of the centers will be reviewed and related to other studies.

Use of NSF Sponsored and Other Materials

To what extent have secondary school level materials been adopted and adapted?

A number of studies have been done since 1967 to determine the use of NSF sponsored materials in public secondary schools. The most extensive study was a survey conducted in 1971 and 1972 by the Center for Science and Mathematics Education (OSU) and ERIC/SMEAC staff. This study (Schlessinger, Howe, White, et. al.) involved a survey of over 6,000 secondary schools from all the fifty states. A sample of responding schools (approximately 2,500 with a student enrollment of over 3,100,000) was selected for analyses.

The use of NSF sponsored materials by sample schools as of June, 1971 is reported in Table 1, page 2. IPS and ESCP were the project materials used most frequently in the junior high schools. BSCS materials were being used in over half of the sample schools, primarily in grade 10. Approximately 44 percent of the students reported to be taking biology were enrolled in BSCS courses. CHEMS materials were being used in 34 percent of the schools, primarily at the 11th grade level and PSSC and Project Physics were being used in 33 and 12 percent of the schools, primarily in grade 12.

These data indicate extensive use of NSF sponsored materials throughout the United States. Comparisons with other studies at state and regional levels indicate these data were reliable as national averages and have a probable error of less than 2 percent. Spot-checks during the last two years indicate ISCS and ECCP materials are now in considerable use, especially ISCS. The use of ESCP and Project Physics has also increased since the survey; it is estimated that the percent of schools using ESCP has increased by about 7 percent, and Project Physics by about the same amount. The percent of schools using PSSC materials appears to have decreased by about 4 percent. The percent of schools using BSCS and CHEMS appears to be about the same.

While there is extensive use of NSF sponsored materials throughout the United States, the amount of use varies considerably between states and within states. Differences between regions of the United States are identified in the Ohio State study. Data regarding use in large states are valid for use and can be provided. Data regarding small states are not valid for comparative use due to sampling procedures and the small number of schools selected.

In addition to direct use of materials, many current textbooks and supplementary materials have been modified to include activities and reading material found in NSF sponsored projects; thus, the use of activities and materials from the projects is really greater than the use of the specific project materials.

TABLE 1

Percentages of Schools and Percentages of Students Using NSF Sponsored Materials

<u>Project</u>	<u>Percent of Schools Using NSF Materials</u>	<u>Approx. Percent of Students Studying the Subject Using NSF Materials</u>
IPS (Physical Sci.)	31	40
ESCP (Earth Sci)	19	25
BSCS Green (Bio.)	27	16
BSCS Blue (Bio.)	20	12
BSCS Yellow (Bio.)	27	16
CHEMS (Chem.)	34	28
CBA (Chem.)	4	2
PSSC (Physics)	33	28
Project Physics (Physics)	12	11

To what extent have elementary school level materials been adopted and adapted?

A number of studies have also been conducted since 1967 to determine the use of NSF sponsored materials in public elementary schools. The most extensive study was a survey conducted in 1971 and 1972 by the Center for Science and Mathematics Education and ERIC/SMEAC staff at the Ohio State University. This study (Helgeson, Howe, White, et. al.) involved a survey of over 9,000 elementary schools in the fifty states. A sample of responding schools (approximately 2,600 schools with a student enrollment of over 1,300,000) was selected for analyses.

At the time the study was completed the percentage of elementary schools using NSF sponsored materials was as indicated in Table 2, page 3. AAAS materials were being used in about 8 percent of each of the grades. The highest use was in grade one and two with 11 percent of the schools reporting use of AAAS materials in those grades. ESS was used in grade five most frequently (7 percent), and averaged use in about 5 percent of all classes. SCIS was third in use averaging about 3 percent across classes. Various other NSF supported materials such as Minnemast, ISCS, etc., were reported to be in use in about 4 percent of the classes. Highest use of the "other" materials occurred in grade five.

TABLE 2

Average Percentage of Schools Using NSF Materials for all Grade Levels and Percentage of Schools at Grade Level of Highest Use

<u>Project</u>	<u>Percent of Schools Using Materials (Average Use Per Grade)</u>	<u>Percent of Schools Using Materials (Grade of Highest Use)</u>
AAAS	8	11
ESS	5	7
SCIS	3	4
Other	4	5

Over 25 percent of the schools reported using NSF supported materials at one or more grade level in their schools. Considering the date of The Ohio State survey, this would suggest wider use at this time. Data obtained on a spot-check basis during the past two years indicate the use of SCIS and ESS has increased extensively. AAAS use has also increased, but not as much as the other two. Other project materials are being used, but not as much as the three cited above. The number of schools using NSF materials at one or more grade level certainly exceeds 35 percent of the schools.

While the data regarding school use of NSF materials were highly reliable, data regarding student enrollments were obtained but reliability checks with schools indicate considerable doubt in the usefulness of the numbers. Some schools indicate a certain program is being used across the entire grade; the reliability check indicated it frequently was not. Other schools reported a single class using the materials; the reliability check indicated other teachers were also using the materials to a considerable extent. Thus, the data regarding numbers of students using each of these materials is subject to extreme error and is not being reported. It appears that the total percent of students using the materials was approximately 10 to 13 percent (1971). No data on numbers are currently available from spot-checks conducted during the last two years.

In addition to the direct use of materials in the classroom, a number of publishers are producing materials with activities similar to those developed for NSF projects. Hence, the use of NSF type materials is greater than the number of schools using NSF sponsored projects.

Variables Related to the Use of NSF Sponsored Materials

What variables have been found that relate to the use of secondary school level NSF sponsored materials?

A number of variables have been identified that relate to the use and lack of use of NSF sponsored materials. Those that can be supported with at least a reasonable amount of data are discussed.

Knowledge of the program or materials must precede adoption or adaption. Studies have been completed that indicate little knowledge is related to little adoption or adaption. Information regarding programs and materials (awareness) is obtained in many ways. Those mentioned most frequently are NSF institutes, college classes, friends, journals, and such information services as ERIC. Awareness is an important and inexpensive procedure if planned carefully.

Once awareness has been achieved inservice institutes, particularly NSF supported institutes, related highly with those who adopt or adapt. A number of studies, including the Ohio State survey indicate NSF sponsored institutes result in extensive use of NSF sponsored materials. Gibney (1971) reported that about two-thirds of those attending 1970 summer institutes implemented some program. His data indicated that about half the implementers had previously decided to implement and about half attended the institute to determine if they wanted to implement. Other studies such as those by Anderson (1971), Whitla (1973), and others support this variable. The importance of a strong awareness program is also supported by these and other data. People who are not aware of alternatives apply to institutes less frequently.

Data from the Ohio State survey indicate that schools that adopt or adapt one course usually select two or more courses. Many schools tend to build programs based on NSF sponsored materials. The initial decision to use one course appears to be a key decision. Since many schools do use a combination of courses, it would appear that consideration should be given to effective use of various combinations of courses.

Larger secondary schools are more likely to use NSF materials than small schools. Reasons for this pattern are not definite. It appears, however, that larger schools have larger numbers of various types of students, more staff, often a science supervisor or department head charged with curriculum responsibilities, and according to a number of studies attend proportionately more NSF institutes than smaller school staff members.

A number of variables appear to be significantly related to the use of NSF materials in several studies, but not consistently. These include (1) philosophical agreement of the teacher with the materials, (2) support of the administration, (3) cost of the materials, (4) student reaction to the materials, and (5) previous use of NSF materials.

While less data are available regarding why schools drop the use of NSF sponsored materials, a review of the literature and our spot-checks during the last two years suggest the following are probably the major variables: (1) negative student reaction to the materials, (2) teacher philosophy (disagreement), (3) too much time required to prepare materials, (4) lack of inservice preparation related to use, (5) dropped use of one set of materials to use another, and (6) the teacher who was teaching with the NSF materials moved and no decision regarding future use had been made. Cost of the materials may be a factor at the secondary level, but prior studies and our surveys do not indicate that it is a major factor in non-use or dropping use of materials.

What variables have been found that relate to the use of elementary school level NSF sponsored programs?

Studies that have been completed regarding variables related to the use of NSF materials at the elementary school level indicate similar relationships, with a few exceptions.

Knowledge of programs and materials are important for adoption or adaption of NSF elementary school science materials. NSF institutes, college classes, journals, and such information services as ERIC are considered to be important as sources of information.

A number of studies at the elementary school level (including The Ohio State elementary survey) indicate that use of NSF sponsored materials is significantly correlated with inservice experience, particularly NSF supported institutes. (This will be discussed.) Analyses of data from the Ohio State study and others indicates that some of those attending NSF institutes had decided to use the materials prior to the institute and were going to the institute for help regarding implementation and actual instruction (the importance of this type of help will be discussed in a later section); however, a large number of those attending institutes have attended to help decide whether they wanted to implement a new program. Of this latter group many do decide to use the NSF materials.

The institute model is a very good diffusion mode for either elementary or secondary school materials; the success in disseminating the NSF materials indicates it probably could be a successful model for other diffusion efforts.

A number of variables appear to be significantly related to use of NSF materials in several studies, but not consistently. These include (1) number of students in the school district; (2) student reaction to the materials; (3) amount of science content preparation (course work) of the teacher; (4) cost of the materials; (5) inservice provided for the teachers; and (6) support of the administration. Spot-checks during the last two years of schools involved in the Ohio State study indicated amount of science content, preparation of teaching, cost of materials, and inservice after adoption to be important.

The data regarding why schools drop the use of NSF sponsored materials is not as well documented with systematic data. A study proposed by the Ohio State University this coming year should provide more data on the topic. Variables that have appeared in the literature and in our spot-checks of schools during the last two

years suggest the following are probably the major variables: (1) negative student reaction to the materials; (2) teacher philosophy (disagreement); (3) too much time to prepare materials; (4) lack of inservice preparation related to use; (5) dropped use of one NSF program to use another; (6) the teacher moved; and (7) cost of materials greater than expected.

Impact of the Use of NSF Sponsored Materials on Teaching Style and Learning

How has the use of secondary school level NSF sponsored materials affected teaching style?

A number of investigators and writers have been concerned with the impact of NSF sponsored materials and other developments on classroom practice and teaching style.

From past research it is quite clear that teachers are more apt to select materials for use (if the decision is theirs) if they agree with the instructional philosophy of the materials. A number of studies, including the Ohio State survey have indicated the use of NSF sponsored materials correlates with more laboratory activity, more pupil centered instruction, and less lecture.

If the above are desired teaching styles and learning styles, NSF sponsored materials facilitate such an environment. Several studies have been completed that indicate a greater use of such activities occur after implementing an NSF sponsored course. Research regarding teacher behavior (Evans, Balzer, and Blosser) indicates that inservice instruction designed to develop specific teacher behaviors are generally quite effective for the desired result.

Studies that have used follow-up samples and control group have found similar results (Ogren and Doran). Instruments such as those developed by Blankenship and Lee have been used by many people and also revised and used. One form, the Science Classroom Activity Checklist has received extensive use in many classrooms. Analyses of these data indicate higher scores by those using NSF sponsored materials compared to those using other materials. Whether the teacher agrees with the philosophy of the program also is important. Teachers who are in strong agreement with the philosophy of the program generally score higher than those who are not in agreement with the philosophy.

While data support the significant influence of NSF materials and institutes on teaching style, many teachers who are using NSF materials and who have been to NSF institutes do not change their teaching styles. Current approaches have not influenced these people to change; if changes in these people are desired, further study is needed to determine how to bring about change. There is some data that suggests people on the negative extreme (opposed to laboratory work and inquiry teaching) may be extremely difficult to influence.

How has the use of elementary school level NSF sponsored materials affected teaching style?

Research regarding the impact of NSF sponsored materials on classroom practice and teaching style at the elementary level is similar to that at the secondary level.

It is quite clear that teachers are more apt to select materials for use if they agree with the instructional philosophy of the materials. A number of research studies including the Ohio State survey, have indicated the use of NSF sponsored materials correlates with more laboratory instruction. Comparisons between earlier studies (Pre-1968) and recent studies (1968-73) indicate more use of lab activities. In addition, there is less use of lecture as an instructional technique in elementary school classes using NSF sponsored materials than other classes. Studies involving many classes indicate these changes are often a result of the use of NSF sponsored materials and/or related inservice work.

How has the use of secondary and elementary school level NSF sponsored materials affected student learning?

Answering this question is considerably more complex than most of the previous questions. It is obvious that the results obtained with most materials is due to the interaction of many variables including the students, the teacher, the materials, the home, and others. A number of the objectives of the NSF sponsored materials are either not easily evaluated or are not evaluated in many research studies; hence, data are not obtained in some studies to permit comparisons with others. My comments that follow recognize these problems, but analyses of data from a number of studies summarized by Ramsey and Howe resulted in a number of statements regarding the impact of NSF sponsored materials on instruction. A review of more recent studies would not cause me to change the general conclusions

made at that time. If NSF sponsored materials were used with students who could understand the materials; (1) content objectives of the NSF course were usually achieved (and better than comparison courses); (2) content of traditional courses was learned about equally as well (though learning of knowledge and comprehension level items was usually lower); (3) process learning was generally higher than comparison courses (when evaluated); and (4) relatively little assessment was made of laboratory skills for either NSF sponsored or other courses.

Nearly all these results were obtained during or shortly after the course. None of the studies used in developing these generalizations were longitudinal studies or retention studies. None of the studies reviewed compared extensive rearrangement of the curriculum such as proposed by unified science advocates.

Studies also indicate that a majority of the students studying most NSF sponsored courses enjoy the courses they are taking. Students normally are positive about the lab activities and pupil centered activities; this, however, is not true of all students. Some do not like these modes of learning and prefer other styles. There is very little research that focuses directly on the problem of learning styles in science education at the secondary school level; most of the research that is available focuses on younger children.

Is the preparation of teachers of science adequate?

NSF institutes were first established to accomplish a number of objectives. Among those were (1) to upgrade the content background of teachers and (2) to improve the instruction of teachers.

If these two objectives are still objectives of the NSF, then several observations are in order.

1. Many secondary school teachers, particularly those teaching earth science, general science, and physical science are not well prepared for what they are teaching (based on content background).
2. The large majority of teachers of science have relatively weak mathematics backgrounds. This is especially true if you eliminate chemistry and physics teachers.
3. Most secondary school teachers do not have a background in the history and philosophy of science.

4. Most elementary school teachers are extremely weak in science content. They usually have had ten or fewer semester hours of science at the undergraduate level and virtually no work in science at the graduate level. Their preparation in mathematics is even less.
5. A large number of teachers are not using much laboratory instruction at the secondary school level.
6. A large number of teachers are not using much laboratory instruction at the elementary school level.

Previous NSF efforts have demonstrated the capability of influencing the preparation and practice of teachers. If structured to do so, future institutes can also improve teacher preparation and change practice. The NSF should determine if the previous goals of NSF institutes are still goals of the NSF. If they are, then action should be taken by NSF to design a program to do so and to plan evaluation to determine the success of the program.

Summary

Research data obtained related to the use and the impact of NSF sponsored materials are summarized.

The extent of use of materials (as of late 1971) appears to be reliable information. No data are available to compare with these sets of data on a direct basis. (ERIC/SMEAC recommends redoing the previous survey, modified based on information obtained in the first study, every four years with a large sample and on an annual basis with a smaller sample.) Data should be obtained to permit trend analysis.

A number of variables related to the use and non-use of NSF sponsored materials have been identified. The ERIC surveys will continue to give data on these. Studies being conducted by others will augment these data and provide comparative data. I question the need for an expanded research program in this area.

Data regarding impact of NSF (and desired use of NSF materials) on teaching style is available though no large sample of classroom data has been obtained on a national sample. Such a study would seem to be worthwhile and provide further information regarding use. Previous studies provide good clues on what to expect.

The impact of the use of NSF materials on student learning at the current time is not established. Past studies indicated the results of the use of the materials. Most of these studies, however, did not consider variations in teaching style, variations in student learning styles and preferences, and prior knowledge. While some of these can be controlled through random sampling procedures, for statistical purposes, lack of the information does not permit kinds of analyses that are needed both in the use of current materials and the design of future materials. Literature searches by ERIC/SMEAC show relatively few large studies regarding the use of various materials. Most studies that have been completed were limited regarding the sample size and regarding the number of related variables investigated. Those that were larger studies were conducted primarily by project personnel.

The impact of NSF institutes has been assessed in various ways. It is clear that they are effective for awareness and diffusion. They also are highly related to teachers using laboratory activities and pupil centered activity (our studies yield correlations with r 's from .05 to .001). While there are relatively few pre-post studies, those that have been done show a change in teacher behavior.

The question that has not been effectively answered is: What are the better types of institute programs for selected samples of teachers? There have been virtually no studies done to assess ways to improve this highly successful approach. Our data suggest the COOP type programs (Summer and follow-up) are probably the most effective for inservice (diffusion and teacher change) for most teachers, however, our studies were not designed to answer that question.

It is my observation that the NSF material diffusion program has been very effective; compared to innovations in education and other fields (such as medicine, engineering, etc.,) it has been outstanding. If new materials being developed are better than the previous materials, it may have been too effective. One inhibiting factor regarding adopting a new program is use of an existing (perhaps expensive) program. The effect of large scale adoption on later adoption should be studied. It is highly possible that a large percentage of the "implementers" who have been teaching three or more years have adopted or adapted past materials. It would be very useful to study in detail non-implementers vs implementers and determine how to work effectively with both groups to obtain desired goals.

Anderson, Ronald D., "Fostering Curricula Change," Science Education, 55(2): 137-142, 1971.

-----, and Horn, Jerry G., "Diffusion of the New Elementary School Science: An Assessment of One Model," Science Education, 56(3): 317-327, 1972.

Anderson, Ronald D., Review of Research in Science Education for the Year 1971, ERIC/SMEAC, Columbus, Ohio, 1973.

Baker, James, A Survey of Science Teaching in the Public Secondary Schools of the Plains, Rocky Mountain and Southeast Regions of the United States in the 1970-71 School Year, Unpublished Doctoral Dissertation, The Ohio State University, 1973.

Baker, Robert Morris, A Study of the Effects of a Selected Set of Science Teaching Materials (ESS) on Classroom Instructional Behaviors, Doctoral Dissertation, Available from University Microfilms, 71-1439, 1970.

Balzer, A. L., Evans, T. P., and Blosser, P. E., A Review of Research on Teacher Behavior Relating to Science Education, ERIC/SMEAC, Columbus, Ohio, December, 1973.

Berger, Carl F., "Change in Predicted Teacher Behavior Based on Experience with an Activity Oriented Elementary Science Course," Available from ERIC/EDRS, ED 080 310, March, 1973.

Berkheimer, Glenn D., "The Science Supervisor and the Utilization of Curriculum Materials," Journal of Research in Science Teaching, 5(1): 20-27, 1968.

Bila, John S., and Bligh, H. F., "Curriculum Patterns in High School Sciences," Paper presented at the 1968 meeting of National Association for Research in Science Teaching, Chicago, Illinois, 1968.

Blackwood, Paul E., Science Teaching in the Elementary Schools, U.S. Department of Health, Education, and Welfare, Office of Education (OE-29059), U.S. Government Printing Office, Washington, D.C., 1965.

Blosser, Patricia E., Inservice Education For Teachers of Elementary School Science, ERIC/SMEAC, Columbus, Ohio, 1969.

Blosser, Patricia E., Inservice Education for Teachers of Secondary School Science, ERIC/SMEAC, Columbus, Ohio, September, 1969.

- Blosser, Patricia E., and Howe, Robert W., "An Analysis of Research on Elementary Teacher Education Related to the Teaching of Science," ERIC/SMEAC, Columbus, Ohio, February, 1970.
- Blosser, Patricia E., and Howe, Robert W., "An Analysis of Research Related to the Education of Secondary Science Teachers," The Science Teacher, 36: 87-95, 1969.
- Buckeridge, Ellen, A Survey of Science Teaching in the Public Secondary Schools of the New England, Mideast, and Southeast States of the United States, Unpublished Doctoral Dissertation, The Ohio State University, 1973.
- Butts, David R., and Raun, Chester E., "A Study of Teacher Change," Science Education, 53: 3-8, February, 1969.
- Carruth, Irby B., "Implementing Curriculum Change in Elementary School Science," Available from ERIC/EDRS, ED 059 867, June, 1969.
- Champlin, Robert F., "A Review of the Research Related to ESCP," ERIC/SMEAC, Columbus, Ohio, January, 1970.
- Chin, Long Fay, "A Survey of Science Teaching in the Public Secondary Schools of the Great Lakes and Far West Regions of the United States in the 1970-71 School Year," Unpublished Doctoral Dissertation, The Ohio State University, 1971.
- Crawley, Harold B., "The Status of Science Education in Iowa High Schools," University Microfilms, Ann Arbor, Michigan, 1967.
- Dungan, Nadine W., "The State of Physics in the State of Illinois," School Science and Mathematics, 70: 327-337, 1970.
- Fornoff, Frank J., A Survey of the Teaching of Chemistry in Secondary Schools, Educational Testing Service, Princeton, New Jersey, 1969.
- Gallagher, James J., A Summary of Research in Science Education for the Years 1968-69, Elementary School Level, ERIC/SMEAC, Columbus, Ohio, June, 1971.
- Gibney, Thomas, Evaluation of 1970 Summer Institutes for Secondary School Teachers of Science and Mathematics, Center for Educational Research and Services, College of Education, University of Toledo, 1971.
- Gorton, Robert G., A Survey of the Status of Science Education in New Jersey, New Jersey Science Teachers Association, New Providence, New Jersey, 1969.

- Hall, Gene E., "Teacher-Pupil Behaviors Exhibited by Two Groups of Second Grade Teachers Using Science-A Process Approach," Science Education, 54: 325-334, October-December, 1970.
- Haworth, Leland J., "Science Education in the Schools of the United States," Report of the National Science Foundation to the Committee on Science and Astronautics, Document No. 44-521, U.S. Government Printing Office, Washington, D.C., 1965.
- Helgeson, S. L., Howe, R. W., White, A. L., And Others, A Survey of Science Teaching in Public Schools of the United States (1971) Volume III - Elementary Schools, Center for Science and Mathematics Education, The Ohio State University, Columbus, Ohio, 1973.
- Hershkowitz, Martin, National Science Foundation, Technical Report No. 01024.01-2, National Science Foundation Program Participation and Secondary School Science Teaching, 1969, Vitro Laboratories, Division of Vitro Corporation of America, 14000 Georgia Avenue, Silver Spring, Maryland 20910.
- Howe, Robert W., and Ramsey, Gregor, "An Analysis of Research on Instructional Procedures in Secondary School Science, Part I - Outcomes of Instruction" reprinted from The Science Teacher, Vol. 36, No. 3, March, 1969.
- Kochendorfer, Leonard H., "Rationale of High School Biology Teachers Using Different Curriculum Materials," University Microfilms, Ann Arbor, Michigan, 1966.
- Koran, John J., Jr., A Summary of Research in Science Education for the Years 1968-69, College Level Science, ERIC/SMEAC, Columbus, Ohio, 1970.
- Kriegbaum, Hillier, and Rawson, Hugh, To Improve Secondary School Science and Mathematics Teaching, A Short History of the First dozen years of The National Science Foundation's Summer Institute Programs, 1954-1965. National Science Foundation - NSF 68-28, U.S. Printing Office, Washington, D.C., 1968.
- Mason, Jerrold William, "A Survey of Science Teaching in the Public Elementary Schools of Two Selected Regions of the United States During the 1970-71 School Year," Unpublished Doctoral Dissertation, The Ohio State University, 1971.
- Maberly, Norman C., "Chemistry Curriculum Patterns in High Schools," Science Education, 51: 343-346, 1967.

- McCurdy, D. W., "Science Education in the Public High Schools of Missouri," University Microfilms, Ann Arbor, Michigan, 1967.
- Merkle, Dale G., "A Leadership Workshop in Elementary School Science: An In-depth Evaluation," Journal of Research in Science Teaching, 2(2): 121-133, 1970.
- National Science Foundation, Enrollment Increase in Science and Mathematics in Public Secondary Schools, 1948-49 to 1969-70, Available from ERIC/DRS, ED 067 263, October, 1971.
- Nicodemus, Robert, "An Evaluation of Elementary Science Study as Science-A Process Approach," Available from ERIC/DRS, ED 027 217, September, 1968.
- Nicodemus, R. B., "Cooperative College-School Science Project - First, Second, and Third Year Reports - 1965, 1966, and 1967," ERIC Document Reproduction Service, ED 013 216.
- Nixon, Lochran C., "Physical Science Offerings, Enrollments, and the Preparation of Physical Science Teachers in Alabama Senior High Schools," University Microfilms, Ann Arbor, Michigan, 1967.
- Novak, Joseph, Review of Research in Science Education (1972), ERIC/SMEAC, Columbus, Ohio, December, 1973.
- Obradovic, Sylvia M., Implementing New Science Curricula and Course Content Improvement Materials, Berkeley, Far West Laboratory for Educational Research and Development, 1970.
- Ogren, James, and Doran, Rodney, "The Effects of Adopting the Revised New York State Regents Earth Science Syllabus on Selected Teacher and Student Variables," Unpublished paper, State University of New York at Buffalo, June, 1973.
- Olenchak, J. J., A Survey of Science Course Offerings in Northern California High Schools, Bay Area Biologists Society, Antioch, California, 1970.
- Orlich, Donald C., "Highlights of the Methods Used by Montana Senior High School Science Teachers: Prior to the Impact of Federal Legislation," Science Education, 51: 18-21, 1967.
- Orlich, Donald C., and Seeling, Robert H., "Idaho Biology Teacher Preparation: A Comparison with the Recommendation of the AAAS Cooperative Committee on Teaching Science and Mathematics," Journal of Research in Science Teaching, 4: 357-363, 1969.
- Patterson, H. R., "A Survey: The Impact of Newer Curricula on Science Teaching," Biological Sciences Curriculum Study Newsletter, No. 45: 5-7, November, 1971.

- Perkes, Victor A., "Junior High School Science Teacher Preparation, Teaching Behavior, and Student Achievement," Journal of Research in Science Teaching, 5: 121-126, 1968.
- Ramsey, Gregor A., "A Review of the Research and the Literature on the Chemical Education Materials Study Project," ERIC/SMEAC, Columbus, Ohio, January, 1970.
- Ramsey, Gregor A., and Howe, Robert W., "An Analysis of Research Related to Instructional Procedures in Elementary School Science," ERIC/SMEAC, Columbus, Ohio, April, 1969.
- Ramsey, Gregor A., and Howe, Robert W., "An Analysis of Research on Instructional Procedures in Secondary School Science, Part II - Outcomes of Instruction," The Science Teacher, pp. 72-82, April, 1969.
- Richards, Phyllis, and Quinn, Patrick V., "The Degree of Implementation of the Elementary Science Curriculum in New York City," Science Education, 52(3): 290-292, April, 1968.
- Rogers, Lola Erickson, Science Teaching in the Public Junior High School, Office of Education (OE-29067), U.S. Department of Health, Education and Welfare, U.S. Government Printing Office, Washington, D.C., 1967.
- Rogers, Parley, "Highlights from a Survey of the CHEM Curriculum in Kansas High Schools, 1969-70," Science Education, 55: 471-476, 1971.
- Rogers, Robert E., and Voelker, Alan M., "Programs for Improving Science Instruction in the Elementary School: Part I, ESS," Science and Children, 7: 35-43, January-February, 1970.
- Roye, J. P., "Modifications of Professional Characteristics of Teacher Participants in National Science Foundation Sponsored Academic Year Institutes," University Microfilms, Ann Arbor, Michigan, 1968.
- Sanderson, Barbara A., and Kratochvil, Daniel W., "Science-A Process Approach, Product Development Report No. 8," Available from ERIC/DRS, ED 064 066, December, 1971.
- Selser, Will L., and Milliken, Don Q., "An Analysis of Factors Successful in the Implementation of Innovative Programs in the Elementary and Secondary Rural Schools - Part II Secondary," Unpublished paper, Presented at NARST, Chicago, Illinois, 1974.

- Schlessinger, F. R., Howe, R. W., White, A. L., And Others, A Survey of Science Teaching in Public Schools of the United States (1971) Volume I - Secondary Schools, Center for Science and Mathematics Education, The Ohio State University, Columbus, Ohio, 1973.
- Smith, Ben Afton, Modern Elementary Science Curricula and Student Achievement, University Microfilms, 73-2519, 1972.
- Smith, Doyne M., and Cooper, Bernice, "A Study of the Use of Various Techniques in Teaching Science in the Elementary Schools," School Science and Mathematics, 67: 559-566, 1967.
- Snoble, Joseph J., Status and Trends of Elementary School Science in Iowa Public Schools, 1963-1966, Unpublished Doctoral Dissertation, University of Iowa, 1967.
- Southerland, Troy Taltson, The Impact of the SCIS Implementation Program on the Teaching Style of Selected Elementary School Teachers, University Microfilms, 73-5588, 1972.
- Swann, Albert Henry, "A Study of Physical Science Instruction in the Public High Schools of Mississippi," University Microfilms, Ann Arbor, Michigan, 1967.
- Thompson, Raymond E, A Survey of the Teaching of Physics in Secondary Schools, Educational Testing Service, Princeton, New Jersey, 1969.
- Trowbridge, Leslie W., And Others, A Summary of Research in Elementary, Secondary and College Levels of Science Education for 1970, ERIC/SMEAC, Columbus, Ohio, 1972.
- Tweeten, Paul W., and Yager, Robert E., "Science Curriculum Trends in Iowa," School Science and Mathematics, 67: 33-37, January, 1967.
- Van Koevering, Thomas E., "Distinguishing Characteristics of High Schools with High and Low Enrollments in Physics," Journal of Research in Science Teaching, 8: 37-39, 1971.
- Walles, James R., History and Development of National Science Foundation Elementary Institutes 1959-67, Available from ERIC/DRS, ED 027 230, December, 1968.
- Webb, Melvin Richard, "Teaching Science in Public Elementary Schools of the Plains, Rocky Mountain and Southeast Regions of the United States," Unpublished Doctoral Dissertation, The Ohio State University, 1972.

- Welch, Wayne W., "The Impact of National Curriculum Projects: The Need for Accurate Assessment," School Science and Mathematics, 68: 225-234, 1968.
- Welch, Wayne W., "Review of the Research and Development Program of Harvard Project Physics," Science Education Information Reports, ERIC/SMEAC, Columbus, Ohio, 1971.
- Welch, Wayne W., "A Summary of Research in Science Education for the Years of 1968-69," ERIC/SMEAC, Columbus, Ohio, June, 1971.
- Welch, Wayne W., and Walberg, H. J., "An Evaluation of Summer Institute Programs for Physics Teachers," Journal of Research in Science Teaching, 5: 105-109, 1967-68.
- White, Arthur L., "The Development of Models to Explain the Relation of Important Variables to Laboratory Instructional Strategies," Unpublished paper presented at the annual convention of the National Association for Research in Science Teaching, Minneapolis, Minnesota, 1970.
- Whitla, Dean K., and Pinck, Dan C., Essentially Elementary Science, A Report on the Status of Elementary Science in Massachusetts Schools, Harvard University, Cambridge, Massachusetts, March, 1973.
- Whitla, Dean K., and Pinck, Dan C., Something of Value, A Summary of Findings and Recommendations for Improving Elementary Science in Massachusetts, Harvard University, Cambridge, Massachusetts, March, 1973.
- Wimberly, Robert C., and Buell, Robert R., "BSCS Biology in Ohio High Schools in 1966," School Science and Mathematics, 67: 703-706, 1967.
- Wittwer, F. A., "Evaluation of the National Science Foundation Research Participation Program for High School Science Teachers at the University of Wisconsin," University Microfilms, Ann Arbor, Michigan, 1967.

2. SOME THOUGHTS ON THE IMPACT OF
NATIONAL CURRICULUM PROJECTS*

by

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In this paper, I consider several ways to assess the impact of national curriculum projects. Impact is defined in the sense of effect, that is, the force of impression or operation of one thing on another. In this instance, the stimulus is provided by the National Science Foundation, while the potential responder is the field of science education. Synonyms for the word impact as it is used here include effect, consequence, result, or outcome, with each word referring to a looser or remoter connection to a known and immediate cause.

National curriculum projects are those multi-faceted, multi-year curriculum development groups that have received National Science Foundation support. A further restriction on the term is the national rather than local orientation.

The rubric I have chosen for this essay was developed by considering the variety of criteria one might use in determining extent of impact. Several areas emerged that are used to focus the discussion; these are:

1. Potential for impact
2. Usage
3. Achievement of NSF goals and objectives
4. Course evaluations
5. Secondary effects
6. Inhibiting factors

*A background paper prepared for the NSF Impact Conference, University of Maryland, August 7-9, 1974.

Because of limited preparation time, this paper will be based on personal experiences in evaluating two national curriculum projects, our work with the Minnesota Research and Evaluation Project, the Eighth International Clearinghouse Report, the Second Handbook of Research on Teaching, recent ERIC reviews of science education, and an ERIC search of relevant literature. My main purpose is to identify areas for further discussion and study, rather than to indicate the degree of impact.

1. Potential for Impact

An appropriate question to consider is the likelihood of impact based on the extent of NSF involvement in curriculum development. Let us examine several facts. During the first eleven years (1956-67) of the course content improvement program (now called Materials and Instruction Development, MID), more than one hundred million dollars was used to support major curriculum projects (Welch, 1968-b). Estimates of support the past seven years are in excess of fifty million dollars, giving a grand total of about \$150,000,000 for the 18 years of the program. While this figure may appear small compared to government cost overruns on some military equipment, it does represent a substantial input into the curriculum research and development effort.

Further evidence of impact potential is available in the Eighth Report of the International Clearinghouse on Science and Mathematics Curricular Developments (Lockard 1972). No fewer than 141 projects in the United States are listed, representing a real proliferation of development activity in science, math, and social studies. Furthermore, 47 of these projects list the National Science Foundation as a source of financial support.

In 1972, NSF was listing 26 principal curriculum study groups under their support. A recent booklet provides an up-to-date summary of the scope of NSF-supported curriculum development. (NSF, 1974). A total of 64 separate Course and Curriculum Improvement Projects are listed together with more than a score of related projects, conferences, and research studies.

By any standard--financial, number of projects, or professional involvement--the investment is extensive. Surely, the potential for impact does exist.

2. Usage

A major criterion for assessing effect is the degree to which the new courses are accepted and used in the schools. I have examined this issue in some detail in a paper entitled, "The Impact of National Curriculum Projects, the Need for Accurate Assessment," (Welch, 1968-a). (This paper is attached as Appendix A as additional background information.) At that time I stated:

This approach has the strong appeal of simplicity and practicality. Admittedly, assessing the impact of a new program by counting the number of students using the materials is not a basis for final judgment of success. This criterion ignores the quality dimension, and probably is a function of propaganda and advertising. But a complete appraisal of the impact of these programs is impossible without it.

However, an examination of the enrollment data for PSSC as a case study in 1968 revealed a number of discrepancies in reported usage figures. I concluded:

...the available information on the acceptance of the PSSC physics course is incomplete; figures are contradictory and without sound statistical basis. A similar situation appears to exist with other course content improvement projects.

and

Thus, it becomes apparent that an assessment of the impact of the course content improvement program, even at the gross level of counting heads, is not reliable....The situation suggests the need for an accurate national sampling of enrollments in science courses. A group directly concerned with this problem could not only carry out systematic surveys of enrollment, but also study the general questions of evaluation mentioned earlier.

Unfortunately, the latest figures I have had reported to me suggest the situation is unchanged today. Usage figures reported by projects are still based on textbook sales with their attendant validity problems of examination copies, single copies sold, texts reused, or used by more than one class. The latest U.S. Office of Education survey of course enrollments (1972-73) will not be available until later this month. Perhaps the figures gathered by Robert Howe and his students at Ohio State will shed some light on this dismal situation.

3. Achievement of NSF goals and objectives

One way to assess impact is to provide evidence that the goals of the course and curriculum improvement program have been achieved. This approach currently suffers from the lack of clear statements of goals and the lack of available evidence relating to these goals. In 1966, the NSF goal was stated as, "The prime objective has been to encourage the development of improved teaching materials in mathematics, science, and engineering through the collaboration of scientists, teachers, and educators," (Clark, 1966).

Although the recent publication summarizing course improvement activity does not speak to goals, other NSF documents hint at general purposes. In a statement before a House subcommittee on science, research, and development,

March 7, 1973, the development of educational materials was deemed important for the improvement of education for careers in science and the development of science literacy. To my knowledge, no systematic study of success in achieving these general goals has been planned. However, it would appear that any attempt to assess impact must include evidence that the program is accomplishing its objectives.

4. Evaluation results

Summative evaluation provides information about the outcomes of a course or curriculum. Such knowledge permits decisions by teachers, administrators, and legislators concerning adoption, impact on children, and prudent use of tax dollars. Certainly, summative evaluation is a key ingredient in assessing the impact of NSF-supported curricula.

Unfortunately, this information is not available. In 1969, only eight (8) of 46 projects reported carrying out summative evaluative research (Welch, 1969). Only four of these projects were known to randomly assign subjects to treatment and, thus, were true experiments. If we accept Campbell and Stanley's (1963) claim that true experiments are the only means of settling disputes regarding educational practice and the only way of verifying educational improvement, then in 1968 we had very little evidence of the impact of national projects.

To test a more recent evaluation situation, I refer again to the Clearinghouse Report (Lockard, 1972). Of the 47 projects which reported receiving NSF support, 18 indicated they had evaluated the effectiveness of their materials. Because different questions were asked about evaluation efforts, exact comparisons cannot be made to the 1968 data. However,

disregarding the seven studies which were a single doctoral thesis as the evaluation reports, and judging the extent of evaluation by the published information available, I would estimate that only nine projects have useful evaluation plans. Thus, it would appear that the situation in 1972 is little improved over that of 1968. This is unfortunate in the present situation because I believe the most useful information on impact will be obtained from national evaluation experiments with random assignment to the treatments of interest. This belief is based on our experience with Harvard Project Physics where the impact of the curriculum on children and teachers is well established (Welch, 1973).

A similar situation exists with the Physical Science for Non-Science Students (PSNS) course. The evaluation design included random assignment to experimental and control groups as well as the administration of both pre- and post-tests. Major findings of impact on students are summarized in the final evaluation report (Welch, 1972).

An ERIC search of NSF-supported curriculum evaluation yielded 33 studies. This is less than two percent of the total number of evaluation studies listed. It is also less than the actual number of evaluations of NSF-supported curricula because the NSF description is not often used by the ERIC abstractors.

The search suggested the existence of several evaluation results for the High School Geography Project, Science--A Process Approach, and Sociological Resources for the Social Sciences, but I did not have time to examine these in detail. I also was reminded of the Social Science Education Consortium's Data Book in which information on social science projects is provided for school personnel. Single data sheets contain summaries of the projects that include evaluation data, comments, and suggestions for use of materials.

Other evaluation studies carried out by individual researchers have been reviewed the past three years and provide information on impact or, in some instances, the lack of effect. (See for example, Gallagher, 1971; Welch, 1972; Anderson, 1973; Novak, 1973). Unfortunately, these studies are usually isolated attempts to assess impact. What appears to be needed is a systematic synthesizing of existing evaluation information that will tell us what we now know and provide a basis for what we still need to find out.

It is interesting conjecture on the reasons for the lack of evaluation reports. Perhaps it is the limited educational research skills on the part of the scientists responsible for the curriculum development task. Perhaps it is a poor track record of prior evaluation attempts. Certainly, the inherent difficulties of the task are an inhibitor. Yet, it was these very characteristics of curriculum development that led to NSF's initial involvement in this problem. The Foundation recognized a need to improve a bad situation. I suspect, if NSF exerts pressure on its project directors to provide evaluation evidence of the same high quality it demands for course content, the situation would vastly improve.

5. Secondary effects

Another way to measure the consequences of new programs is to examine the spin-off or secondary effects of the program--the activities or products spawned under its influence. The potential impact here is large, but the existence of convincing information is small. Thus, these potential secondary effects become prime candidates for further study. Probable secondary effects include:

a. Commercially produced science texts.

Although in many fields the "old" standby texts still dominate the market, recent revisions reflect changes in content, style, methodology, and philosophy. It would be interesting to compare text changes in science during the decade of the fifties with changes that may have occurred from 1965 to the present. Perhaps an examination of text revisions in a non-science area, e.g., English or history, would provide a useful comparison base.

Another recent development is the commitment of publishers to involve groups of scientists and educators in their development work, to trial test the materials and revise accordingly.

b. Tests and measurement.

The new curricula have probably forced changes in most of the standard tests used in science and mathematics education; for example, the SAT subject matter tests, New York Regents exams, and National Assessment tests. In addition, a variety of new tests have been created by such groups as BSCS, PSSC, CHEM and HPP. There is probably influence on the widely used STEP, Iowa, Dunning, and Stanford tests, but documentation of the nature of this effect is not readily available.

c. Laboratory and demonstration equipment.

One overriding characteristic of the new programs was the development of new equipment for use in the science laboratory. This equipment has been adopted and adapted by most private firms, yet the NSF flavor is evident. Quantification of this influence may provide valuable impact information.

d. Teacher training.

To what extent have the national curriculum projects fostered changes in the content and process of training science teachers? I suspect the influence is great, yet no careful study of this effect has been carried out.

e. Present and past project staffs.

With more than six dozen projects funded, the number of teachers and professors working on these projects must number above 5,000. These people have been influenced by their work on the projects and have spread this influence to their new jobs. Communication networks have been established, scientists have become educators, teachers and professors have communicated, and vast comradeships have evolved focused about a single new alphabet program.

The personal mobility of project staffs and the influence on their professional development is a potentially rich field for further study.

f. Changes in students.

Knowledge of the scientific enterprise, changes in attitude, favorable occupational decisions, and the like, should be part of the systematic evaluation advocated in Section 4. It is mentioned again here to acknowledge the need for student outcomes beyond the normal achievement test criterion.

g. Teachers and teaching methodology.

To the extent that curriculum materials have influenced teachers and teaching, here again is a possible area for detecting secondary effects.

In a direct manner, the many NSF-supported teacher institutes have been influential. But it is hypothesized here that teachers have been affected by the mere contact with the new programs. Again, research is warranted to test this hypothesis, both in the quantity and nature of impact.

h. Long-term effects.

Precollege students who participate in the new courses could be expected to behave differently five years after the experience. These changes could be manifested in such things as career choices, attitude, and selection of college science success. Watson (1973) has completed a study that indicates long-term consequences of Harvard Project Physics. Perhaps other studies are called for to determine impact over several years. This may be particularly important for the NSF goal of providing a talent pool for career choices in the sciences.

6. Inhibiting factors to impact

As part of the background work for the preparation of this paper, the staff of the Minnesota Research and Evaluation Project considered factors which might inhibit the impact of NSF-supported curricula. Some educational critics (e.g., Silberman, 1970) have claimed that the curriculum development movement has had very little impact on schools. Although I do not agree with the conclusions reached by Silberman, I do think that the profession and the Foundation have been remiss in not providing evidence to indicate the extent of impact. Areas for further study might include examining those factors which might reduce the impact potential. I will mention a few of these as possibilities which might stimulate the conference to suggest work in this area.

It should be pointed out that very little information is available to support or refute the detrimental nature of these factors on the impact of national curriculum projects; however, they are presented here, without comment, for your consideration.

- A. High costs to schools to adopt new programs.
- B. Loss of professionals from schools to become involved in national curriculum projects.
- C. Lower scores that have appeared on College Board tests and the decline in scores on the common science items for the first two cycles of the National Assessment testing.
- D. Generation of negative attitudes toward science on the part of the lay public because of the high difficulty level associated with many new curriculum projects.
- E. Concentration of the new programs on science content rather than on effective methodology for teaching.
- F. The national curriculum projects may have become the spawning ground for the severe criticism of education that has appeared during the sixties and early seventies. If it is easy to criticize current science programs and then plunge millions of dollars into improving them, it seems but a short step to generalize to the total precollege schooling experience, as well.
- G. Rejection of emphasis on the basic R's of education.
- H. Interference of the federal government into the local control of the schools.

- I. The adverse publicity generated by the anti-evolutionists and those opposed to the social science projects.
- J. Lack of substantial evidence of value of the new programs for the number of dollars that have been expended.

The list of possible factors that may prohibit a strong effect in science education by NSF programs is long and somewhat frightening. If the claims made by those opposed to the curriculum development program cannot be refuted, then the potential for positive impact of national curriculum projects is greatly diminished. I would urge in this paper that this is not the case but, rather, there has been a failure to give the same degree of systematic attention to evaluation and dissemination that has been given to curriculum development. Let us hope that this conference will provide the impetus to document the impact of this major curriculum reform effort.

REFERENCES

- Anderson, Ronald D. "Review of Research in Science Education for the Year 1971." SMEAC Report, ERIC Information Analysis Center (mimeograph). Ohio State University, Columbus, Ohio (April 1973), 70 pp.
- Campbell, Donald T. and Stanley, Julian C. "Experimental and Quasi-Experimental Designs for Research on Teaching." Handbook of Research on Teaching. (Edited by N. L. Gage.) Chicago: Rand McNally, 1963. Pp. 171-246.
- Clark, George M. (Ed.) "The Course Content Improvement Programs of the NSF." Staff, Division of Pre-College Education in Science. In the BSCS Newsletter, 28. Boulder, Colorado (April 1966), 15.
- Gallagher, James J. "A Summary of Research in Science Education for the Years of 1968-69, Elementary School Level." SMEAC Report, ERIC Information Analysis Center (mimeograph). Ohio State University, Columbus, Ohio (June 1971), 65 pp.
- Lockard, J. David. "Eighth Report of the International Clearinghouse on Science and Mathematics Curricular Developments 1972." Science Teaching Center, University of Maryland, College Park, Maryland (1972).
- National Science Foundation. Course and Curriculum Improvement Projects. Publication E 74-30. Washington, D.C. (June 1974.)
- Novak, Joseph D. "A Summary of Research in Science Education--1972." SMEAC Report, ERIC Information Analysis Center. Ohio State University, Columbus, Ohio (December 1973), 107 pp.
- Silberman, C. E. Crisis in the Classroom. New York: Random House, 1970.
- Watson, Fletcher G. "A Follow-up Study of Project Physics Students." Harvard University. (Unpublished monograph) (1973).
- Welch, W. W. "Curriculum Evaluation." Review of Educational Research, Vol. 39, No. 4 (October 1969). Pp. 429-443.
- Welch, W. W. "Evaluation of the PSNS Course II: Results." Journal of Research in Science Teaching, Vol. 9, No. 2 (1972). Pp. 147-156.
- Welch, W. W. "Review of Research 1968-69 in Secondary Level Science." Journal of Research in Science Teaching, Vol. 9, No. 2 (1972). Pp. 97-122.
- Welch, W. W. "Review of the Research and Evaluation Program of Harvard Project Physics." Journal of Research in Science Teaching, Vol. 10, No. 4 (1973). Pp. 365-378.
- (a) Welch, W. W. "The Impact of National Curriculum Projects, The Need for Accurate Assessment." School Science and Mathematics, Vol. LXVIII, No. 3 (March 1968). Pp. 225-234.
- (b) Welch, W. W. "The Need for Evaluating National Curriculum Projects." Phi Delta Kappan. (May 1968). Pp. 530-532.

3. EXAMPLES OF CHANGE IN SCIENCE CURRICULA

(Suggestions by Dave Lockard for Possible Discussion - 8/74)

1. Updated science information
2. Factually more accurate data
3. Inquiry and discovery approach type teaching
4. Less expensive science teaching equipment
5. Science as investigation and process
6. Cooperative multiple authorships among scientists, science teachers and science educators
7. More active student involvement
8. Biology using living materials - not so much pressed, pickled & preserved
9. Chemistry using more open-ended experiments, less "cook-book" work
10. Physics studying energy and less technology
11. Earth-Space integrating larger numbers of the sciences
12. Improved science teacher training - more content & better education
13. More international awareness and sharing
14. More emphasis on principles and concepts, less on facts
15. More research emphasis on how students should learn rather than that to be learned
16. Re-evaluation of specific content
17. More curriculum coordination and development of K-12 programs
18. More problem-solving situations than memorization exercises
19. More laboratory investigations than lectures
20. More inductive than deductive reasoning situations
21. More specifying of overall course objectives
22. More built-in curriculum evaluation
23. More built-in student learning evaluation

24. Involvement of teachers in pre-service and in-service training
25. More use of multi-media approach to instruction
26. More "total package" instructional packets
27. An active involvement in curriculum planning by all those who could contribute to such work
28. More awareness of individual student needs
29. More flexible lab furniture and facilities
30. More monies to science education

4. POSSIBLE AREAS OF NSF "IMPACT"

(Suggestions by James Wailes for possible discussion.)

TEACHER EDUCATION

1. What changes have occurred in teacher education as a result of N.S.F.?
2. Criteria for selection of participants in N.S.F. programs? Are these persons really change agents? What proof do we have?
3. Is there a satisfactory model for teacher change?
4. What changes have taken place with a run of the mill teacher?
5. What changes have taken place in teacher attitudes as a result of N.S.F.?
6. Has there been an effect on college science teaching?
7. Role and preparation of the so-called science supervisor?
8. Time studies of science supervisor and role in in-service training.
9. Model for effective inservicing teachers to get them activity inclined.
10. What evidence of impact on preservice education in colleges and universities?
11. Possibility of funding projects designed to help teachers use junk and homemade equipment.
12. Informational programs for groups of administrators, supervisors and teachers on implementation.
13. Conferences of college personnel interested in researching some of these problems.
14. As teachers become aware and competent, how much interaction and infusion have they had?

CHILDREN

1. Possibility of some long-term studies. (SAPA has data) (Process instrument)
2. What happens to "hands on" elementary children when they go into "hands off" junior high? (Mesa, Arizona - SCIS. 96 out of 100 chose science - other, 5 out of 100 - figures approximate)
3. Curriculum research - Kellogg at Oklahoma. Reading readiness and science - how does it tie in other areas.
4. Data on children in child-centered programs.
5. Nature of learning in science education. What takes place in children?
6. Values clarification. What is science's responsibility in this area? How?
7. Accountability - Measure student achievement. Instrumentation?
8. Let's look closely at the middle school curriculum, rationale, adolescent psychology.

IMPLEMENTATION

1. Determine factors in a school system that would allow change. Has N.S.F. been pushing the right direction?
2. There is little research on analysis - values of various programs. Who should determine the values? (In 1971 ERIC Center reported 375 studies and only 4 were historical or philosophical analysis.) Assumptions are made and no one challenges.
3. There are a lot of studies comparing "new science" to old, but poorly designed. Must really try to do better comparative studies.
4. What evidence is there on the interaction between the ivory tower and the "real world" - also intra-university.

5. What do teachers need before implementation can happen?
6. How do we implement? Compare English and U.S.?
7. What effectiveness has the "multiplier" idea had?
8. Define responsibility of college and university in implementation.
9. What is the feasibility and potential of a Science Education Consortium?
10. Articulation in K-12 curriculum?
11. Are there models on successful adaptations and implementation schemes?
12. After N.S.F. funds are withdrawn what happens?
13. Role of sales-persons in implementation. Good pattern? How trained?
Role of science supervisor?
14. What about NAEP?
15. College and university role with pre-service.
16. Is pattern on implementation apparent and why?
17. Can there be a launching of these programs without commercial kits?

EVALUATION

1. Close look at objectives and content.
2. Data book idea (Social Science)
3. Are programs ecologically sound? (Ecopornography)
4. Role of taxpayer in expenditures.
5. How do these programs tie in to Competency-Based Teacher Education?
6. Effectiveness of self-paced instruction, individualized management.
7. Study groups to pick and choose from various curricula.
8. The influence of N.S.F. funded programs on other text publications.
9. How has injection of federal funds into universities influenced universities?

MISCELLANEOUS

1. Fund some curriculum projects in which needed materials cannot be obtained in kit form. Difficult financial situation.
2. What has been the impact of N.S.F. on educational level? More Ph.D.'s and M.A.'s (N.S.F. did a study such as this)
3. What impact has been made on scope and sequence, teaching strategies? They are different! Was the intent there?
4. What has been the impact of scientists on educators and vice versa? Have we moved in a common direction?
5. Has there been an impact? If so, upon whom?
 - a. elementary school children
 - b. secondary school children
 - c. college students
 - d. pre-service methods
 - e. inservice
 - f. non-N.S.F. programs
 - g. foreign curricula

B. Possible Categories of Impact Studies
(Welch & Lockard)

	USE	LEARNING	CHANGES	CONDITIONS (FUTURE)
<u>PEOPLE:</u>	X	X		
Classroom Teachers				
Elementary				
Secondary				
College				
Adults (Continuing Education)				
Students - All levels of above				
Administrators				
Lay Public				
Supervisors & Counselors				
<u>MATERIALS:</u>	X	X	X	
Texts				
Tests				
Media				
Classroom Facilities				
Laboratory Furniture				
Supplemental Classroom Materials - (Programmed, Readers)				
<u>METHODS:</u>	X		X	
Teacher Training				
Learning				
Teaching Styles				
Evaluation Methodology				
Research				
<u>INSTITUTIONS & SYSTEMS:</u>			X	
Professional Societies				
Publishing Industry				
Manufacturing of Equipment				
State Departments of Education				
School Systems				
Colleges and Universities				
<u>PROGRAM:</u>			X	
Pre-school				
Elementary School				
Junior High School				
Senior High School				
Undergraduate - (2-yr., 4-yr.)				
Graduate -				
Adult and Community Education				

C. Possible Studies

This section contains the reports of the four sub-groups on studies that could be made on the impact of NSF.

1. Studies to Assess Changes in Institutional Structure Resulting from NSF Programs

(Paldy and Hurd)

Rationale

Two decades of NSF curriculum development, teacher training, and implementation projects have made a substantial impact upon various parts of institutional structures. Many universities and colleges are beginning to modify pre-service teacher preparation programs to provide better training for teachers who will be required to use new materials. NSF in-service training activities have evolved into wide-ranging programs of continuing education and extension services. University-school relationships have been developed in a variety of ways that previously had not been exploited and, indeed, would have been unimaginable a decade ago.

Many introductory university courses have been modified to reflect changes in secondary programs that were stimulated by NSF materials. Special part-time degree programs have been established at many institutions as a direct result of NSF teacher training programs.

Finally, small changes have been made in university reward systems that permit faculty to participate in activities that extend beyond traditional disciplinary areas and, in some cases, far beyond the confines of the university campus. Universities are beginning to establish criteria by which creative work in science curriculum research and development can be judged, and it is no longer uncommon for outstanding work in science education to be acknowledged by the award of promotion and tenure. To the extent that one believes that reward structures are major factors in influencing faculty behavior, one must conclude that NSF programs and materials have contributed significantly to whatever small progress has been made.

Plan of Activity

Each element described above could be analyzed in a clinical study at a representative sample of institutions. It is essential that the study be done in depth if the institutional changes are to be sharply illuminated. A clinical approach, as contrasted with a purely statistical one, will view each institution as somewhat unique, requiring an appraisal of the total setting in which the changes have taken place.

The sample should include institutions of various types, ranging from large state universities to small liberal arts colleges. The study could be performed by an outside faculty member spending the year as the institution as a visitor.

CHANGES IN PROGRAMS

Hurd & Paldy

The NSF curriculum improvement programs have had a major influence on the theory and practice of curriculum development. Some of those influences have been:

1. The use of research scientists to select and validate subject matter especially in terms of its up-to-dateness and conceptual worthiness.
2. The organization of curricula in terms of conceptual themes, theories or strands to provide a logical continuity of subject matter.
3. The development of science curricula for the elementary schools that were based upon authentic science concepts.
4. The stress on direct investigation of phenomena by students using the resources of the laboratory and field.
 - a. The introduction of inquiry processes into the elementary school.
5. The support of alternative curricula for every grade level or subject field.
6. The development of curriculum-supportive materials such as supplementary reading and projected materials, simplified laboratory equipment, and student tests. Teachers' guides and handbooks were developed which were more adequate than any produced in the past.
7. A variety of course or curriculum organizations were tested: these ranged from independent modules (ESS) to the hierarchial arrangement of Science: A Process Approach.

The NSF curriculum projects stimulated a wide range of educational research.

1. There were numerous efforts to determine whether the NSF sponsored curricula were more "effective" than the corresponding conventional programs. (The conceptual flaws and weakness of the research design of these studies is recognized but they did bring about a renewed interest in science education research).
2. The elementary school science programs stimulated hundreds of studies on what can and cannot be learned. Developmental stages and learning levels were not widely recognized as areas of science education research before the advent of the NSF elementary science programs.
3. The concepts of "formative" and "summative" evaluation obtained a considerable part of their meaning through efforts within the NSF curriculum projects.

Educational Research

Rationale

The development of the National Science Foundation as a significant factor in American science education in the last two decades has triggered an explosion of research in science education. Many hundreds of studies have been done to evaluate the results of introducing new materials and techniques in the science classroom. Despite the existence of a large body of research information, most teachers and school systems pay little attention to it as they go about their day-to-day activities.

Plan

The Foundation should attempt to evaluate the effectiveness of research in science education. It should seek to ascertain whether some methodologies are more useful than others, and whether the field as a whole has been fruitful. Have hypotheses been developed which have cut across disciplinary lines? Have some hypotheses succeeded in generating others which appear to be more powerful? Do research results exist which the entire educational community accepts by virtue of their generality and predictive power? The Foundation should seek to determine which of the sub-fields of research in science education are most likely to be productive before investing its diminishing resources in an attempt to measure NSF program impact. Specifically, it should obtain an answer to the following question: Why is most educational research read only by other researchers?

Change Agents

Rationale

A surprising number of teachers who have participated in NSF programs have rapidly advanced in the education hierarchy. Some have left the schools to teach in colleges and universities, while others have become school leaders. Talented individuals with leadership potential are a nation's greatest resource. It is important that we understand how we can best go about identifying those persons who are most likely to repay an investment in their training by displaying high productivity in their chosen fields. Is there a causal relationship between NSF training and professional productivity, or do potential leaders seek to participate in NSF programs in numbers that are out of proportion to their representation in the population as a whole?

Plan

Since NSF has played a major part in the in-service training of teachers during the last twenty years, it would be useful to examine whether there are any general lessons to be learned. Is the setting in

which the training is provided important? Are campus programs more effective in stimulating leadership than in-service programs held in school systems? Are some program formats more effective than others? Many of these questions might be answered in a longitudinal study using clinical (as opposed to purely statistical) methodology.

Future Trends Warranting Examination

(Hurd & Paldy)

Dissemination Models

The process of curriculum diffusion, adoption, implementation and maintenance is in the need of special study. Aspects of the process have been studied but not the process in its entirety. Those studies might include such elements as the need for curriculum change as well as adaption of curricula to local needs and conditions.

Some models should be broad enough to include the entire school organization in relation to curriculum innovation. The extensive work that has been done to study the diffusion of agricultural and technological innovations can undoubtedly provide us with useful techniques.

Change in Corporate Relationships & Patterns of Activity

Rationale

The large-scale NSF effort in curriculum development has produced a number of new relationships among publishers, the Foundation, universities, non-profit development laboratories, and the schools.

Precedents have been established in many areas that will continue to have an impact upon organizations and programs. These include royalty repayment arrangements, copyright and free-use policy, new hardware-software packaging and distribution mechanisms, marketing plans, and the development of working relationship among publishers, authors, and non-profit development groups.

Plan of Activity

It would be extremely useful if these new organizational patterns and practices were studied in an attempt to generate developmental models that could be used to provide guidelines to others. Special attention should be given to areas that have proven to be troublesome, such as curriculum revision procedures and related matters. The economic aspects of many of these relationships may be modeled mathematically using standard techniques of operations analysis.

Low Turn-Over of Teaching Population

Rationale

Declining school enrollments are already exerting a significant influence on school staffing patterns and teacher employment possibilities. As the number of available positions is reduced, teachers will lose employment mobility and may become less interested in attending summer training programs which do not provide stipends and which do not increase opportunities for better positions. In view of this trend it may be useful to examine alternate delivery mechanisms for providing in-service training such as television (video-tape cassettes, cable, etc), correspondence courses modeled somewhat along the lines of the British Open University Program, and "Chatauqua" programs now being sponsored for college and

university teachers. In view of the cost advantages associated with these programs, projects of this type would appear to be of very high priority.

Plan of Attack

A pilot grant could be made to establish an "alternate-mode" training program and an evaluation project supported to examine its achievements. It might be possible to compare the results of such a project with those of a more traditional training activity. This study should also seek to ascertain whether attitudinal changes associated with school retrenchment are inimical to curriculum experimentation.

Collective Bargaining Trends

Rationale

It is clear that collective bargaining in the schools is about to become a permanent feature in American education. Bargaining agreements have already served as barriers to the development of in-service training programs that would have required teachers to participate at times of that day that were not previously negotiated. It is apparent that NSF should take the initiative in attempting to develop a positive relationship with national groups that will pave the way for more productive relationships at the local level.

Activity

The Foundation should study the effectiveness of a pilot grant made to a major national teacher organization to support an in-service activity that is matched to their capabilities. Typical activities might include the dissemination of information about new programs through organizational publications, or the operation of appropriate training programs with consulting assistance. Monitoring of pilot grants may make it possible to determine if the plan is effective. It is particularly important that efforts be made to encourage teacher organizations to assume more responsibility for increasing the effectiveness of science instruction.

Revenue Sharing

Rationale

In view of the diminished resources likely to be available for educational programs during the next decade, the Foundation should examine the feasibility of using state agencies and universities to make grants to school districts that would work in close cooperation with them.

Local problems and capabilities may be more accurately gauged by persons familiar with the region than by persons who rarely leave Washington. A plan that enabled the local institution to make awards (on a competitive basis) might also make it possible to distribute federal funds in a more equitable manner.

Plan

The Foundation should make a pilot grant and monitor its effectiveness. An attempt should be made to audit the managerial costs of such a program to make an accurate determination of indirect costs. Perhaps the off-campus rate should be used.

New Technology

Rationale

New devices such as electronic calculators and electrostatic copiers may eventually exert a significant influence on educational programs if they can be linked with appropriate curriculum materials. At the opposite extreme, aggressive corporate marketing can produce situations where expensive devices are purchased without first preparing the proper foundation, diverting scarce educational capital from more productive uses.

Plan

Studies should be supported that focus on attempts to assess the utilization of such devices in science education programs. The study should examine the relationship between the device in question and the associated curriculum materials. Are there models for the development and utilization of these materials that are replicable in a wide variety of situations? What are the operational characteristics of successful programs with significant technological components.

Previous Adaptations

There is need to study the conditions and constraints that lead to the adoption, rejection, and modification of innovative science programs. Studies which explore the decision-selection process in schools should be supported and efforts made to establish valid criteria. These criteria should be studied for the influence:

- (1) that changes within disciplines might have on them; and
- (2) that shifts in social, economic, and political conditions may have on the major goals of education.

Alternative Schools and Use of the Community

The student uses his knowledge of science for the most part in the context of society and in terms of problems and issues related to the local community. It seems reasonable that a part of his learning should be imbedded in problems and issues of the community rather than entirely within problems of the disciplines. Models and curricula for using community resources in all kinds of ways should be explored: this might include the use of museums and the natural environment as data sources, etc.

Social Awareness

Curriculum projects should be encouraged which incorporate modules on the function of science in contemporary society. These materials would demonstrate how science and technology relate to the programs and wellbeing of humans. They would of necessity need to be interdisciplinary and focus on the science-society interplay. The concepts of social responsibility in science and technological assessment would be essential themes in such curriculum projects.

Competency Based Teacher Education

Studies should be made of projects which relate teacher education programs to the professional functions of the science teacher. A science teacher is an interpreter of science, whose primary function is the development of scientific and technological literacy within the general public. Typically, however, the training of the science teacher is not significantly different from the training afforded a potential research scientist during the first few years of his education. A potential teacher should be trained explicitly for the functions he or she will have to perform in school, and operational criteria must be established to assess teacher performance.

2. Studies of Learning (Moses and Townsend)

In keeping with the charges of the conference specifically the impact on student learning, this sub-group outlined the task into four areas: criteria, students, factors and possible procedures.

Rationale

The assessment of student performance is determined by measuring a number of criteria basic to learning such as: knowledge, skills, attitudes and application. In measuring the extent of learning, levels of student progress should be recognized and monitored. In addition, certain influencing factors must be taken into account. An evaluation system on the impact of learning should be established and maintained for decision makers in science education through the collaboration of researchers, classroom teachers and administrators.

Plan of Activity

An assessment must be made of the needs for studies within the matrix of factors which may influence the learning of students with specific backgrounds, characteristics and aspirations. Small pilot studies should be conducted in sample areas where funded programs are in operation to determine the utility of instruments and the feasibility of gathering data useful in evaluating student learning. Successful pilot studies should be followed by broader studies to determine the affects of NSF curriculum projects. This can more effectively be done by training teachers to gather appropriate data within their classrooms with a mutual understanding of the problem being studied by science education researchers. The researchers who analyze the data from classrooms must communicate their findings in an understandable format to allow application and implementation of the results by decision makers.

Criteria

To evaluate the effectiveness of learning, it becomes necessary to establish and maintain measurements for the following examples of criteria:

Knowledge	Transfer
Abilities	Logical reasoning
Skills	Problem solving
Attitudes	Laboratory investigations
Scientific Literacy	Application to any "real" life situations

Students

To determine the measure of learning as specified in delineated criteria, levels of progress should be monitored.

Student: Entering characteristic at each project level outcomes of each project exposure subsequent science courses
Life activities
 Vocational
 Avocational
 Continued awareness

Factors

In monitoring progress, factors within the students' real and imagined environment should be identified and considered in the total evaluation

Factors: Teachers	Instructional Materials
Peers	Equipment
Parents	Facilities
School setting	School Finances
Community	Size of schools

Possible Procedures:

To design and implement research studies on the effects of NSF curriculum projects on student learning couched in theoretical frameworks and potentially useful to decision makers it is imperative for science education researchers to collaborate with classroom teachers and administrators each step of the way.

- Step 1. An assessment must be made of the needs for studies within the matrix of factors which may influence the learning of students with specific backgrounds, characteristics and aspirations.
- Step 2. Adoption, modification or development of instruments to measure student levels on specified criteria should be made on the identified needs.
- Step 3. Small pilot studies should be conducted on sample populations to determine the utility of instruments and the feasibility of gathering data useful to the evaluation of student learning.
- Step 4. Successful pilot studies should be followed by broader studies to determine effects of NSF curriculum projects on student learning within the various sets of influencing factors. This can more effectively be done by training teachers to gather appropriate data within their classrooms with a mutual understanding of the problem being studied by science education researchers.
- Step 5. The researchers who analyze the data from classrooms must communicate their findings in an understandable format to allow application and implementation of the results by decision makers.

3. Studies on Use (Howe & Wailes)

There are many ways that impact of an innovation can be assessed. Those desirable, useful and feasible types of variables should be assessed on a regular basis. These are: (1) extent of use of materials by schools, teachers and students; (2) use of materials in classrooms (teacher style); and (3) student and teacher reaction to materials used. Other data regarding school systems, facilities, equipment, programs and staff should also be obtained to relate the these three mentioned above.

Assessment of Teaching of Science in Grades K-12

Rationale

The improvement of science education in elementary and secondary schools is one of the major goals of the National Science Foundation. Considerable effort and funding has been provided to develop new curricula and to provide education for teachers of science. The current impact of such efforts and monies is not certain. Hence, contued study is needed to determine extent, quality and duration of use of educational materials. Such research would provide useful information on current use, provide guidance for needed inservice and preservice education, and yield useful information for future curriculum development.

Suggested Research

It is recommended that a rational investigation be conducted concerning the teaching of science in the United States for grades K-12 during the 1974-75 school year. The investigation should obtain data regarding (1) use of materials from principlas and teachers; (2) teaching practice (style) from teachers and students; (3) teacher and student reaction to materials; and (4) desired curricular changes from administrators and teachers. Selected situational variables should also be studied. The research should make use of past impact studies and consider use of national survey techniques currently available. Consideration should be given to the establishment of a periodic update to maintain current information and to provide data for trend analysis.

Assessment of Teaching of Mathematics and Social Science/Studies in Grades K-12

Rationale

The improvement of mathematics and social science/studies education in elementary and secondary schools is also a major goal of the National Science Foundation. As in science education, continued study is needed to determine extent, quality, and duration of use of educational materials. Such research would provide useful information on current use, provide guidance for needed inservice and preservice eudcation, and yield useful information for future curriculum development.

Suggested Research

It is recommended that national studies be conducted concerning the teaching of mathematics and social science/social studies education for grades K-12 during the 1974-75 school year. The investigations should obtain data regarding (1) use of materials from principals and teachers; (2) teaching practice (style) from teachers and students; (3) teacher and student reaction to materials; and (4) desired curricular changes from administrators and teachers. Selected situational variables should also be studied. Consideration should be given to the establishment of a periodic update to maintain current information and to provide data for trend analysis. These two investigations and the science education study should be coordinated to avoid unnecessary duplication of data collection and effort.

USE (Howe & Wailes) continued

Assessment of Impact of NSF Implemented Projects on Participants and Schools

Rationale

Participants attending NSF funded implementation projects in mathematics, social science and science are a valuable source of data to determine the effectiveness of the dissemination projects. The primary purpose of an implementation project is to give first hand experience, with information about, and a general orientation to the materials, teaching styles, and use of the materials in schools.

After attendance at an implementation activity, in either of the three areas, the participants could provide data on the effectiveness of the project, how well the objectives were met, and other implementation suggestions which originated with the individual implementation project.

The feedback obtained could be used by the National Science Foundation and the sponsoring institution to further improve implementation activities.

Suggested Research

It is recommended that pre and post data be collected on NSF implementation activities in math, science and social studies participants about their perceptions of the activity achieving the stated objectives. Such data would include knowledge of curriculum materials, use of materials, and teaching styles.

Assessment of Preservice Education Regarding NSF Curriculum Developments.

Rationale

Beginning teachers entering the profession need to be aware of styles of instruction and knowledge of curriculum materials originating with the NSF funded curriculum projects. At the present time, we do not know how extensively these facets are considered in pre-service methods classes in the areas of science, mathematics and social sciences (studies).

It is recommended that a nationwide study be carried out which would provide information on how much the beginning teacher knows about NSF materials development projects including curriculum materials and teaching styles.

In order for these materials to be included in the schools it is essential that pre-service teachers receive exposure to the programs in their area of interest. While such a study will provide information about the beginning teacher the researchers would be able to ascertain the knowledge level of persons who are teaching the college and university methods courses.

From such a status study, it would be possible to plan dissemination projects for the pre-service teacher education programs.

4. Studies on Personnel Affected, Evaluation Strategies, and Dissemination Plans
(Lockard and Welch)

a. Personnel Affected

1. Students - elementary, secondary, college, adult
2. Teachers - science, math, elementary, others
3. College Professors
4. Supervisors
5. Principals
6. Guidance counselors
7. Publishers - texts, reference materials, readers, programmed materials, teachers guides, student guides
8. Text-book writers - new breed
9. Manufacturers - equipment, furniture
10. Architects
11. Builders
12. Scientists
13. Newspaper writers
14. Proposal writers
15. Professional organization directors
16. Curriculum developers
17. Curriculum evaluators
18. Curriculum Selection Committees
19. Computer programmers
20. Librarians
21. Parents
22. Illustrators
23. Designers of Classroom and Laboratory Furniture
24. Citizen Action groups
25. Local, state, and federal governmental legislators
26. Maintenance personnel
27. Resource site personnel
28. Land use planners

b. STRATEGIES FOR EVALUATION OF NSF CURRICULUM IMPLEMENTATION PROJECTS

The effective use of funds for curriculum implementation nationwide depends in part on the evaluation of individual projects. Evaluation is both an ongoing, formative process (usually undertaken by the projects' personnel) and a judgemental, summative conclusion. The latter is important for decision-making about refunding individual projects, types of projects, and the whole concept or purpose of all projects. Who makes the conclusion and how it is made are the subjects for this brief.

The first problem is the selection of the summative evaluator. The primary need is for an objective assessment of the worth of the products and outcomes of each project. Most evaluation theorists and experts agree that it is extremely difficult for persons associated with a project to provide an objective evaluation, so that an external evaluator is a necessity. An external evaluator does not guarantee objectivity but does reduce the subjectivity of the evaluation. Further reduction is made by the selection of competent evaluators.

No certification board or association exists in educational evaluation, as in medicine or law, so that at present reliance on professional judgement seems the best course. Persons and organizations recognized by the educational community to be competent in evaluation should be utilized for the evaluations. The logistics of evaluating several hundred projects of varying size, type, and location are suggestive of a central clearinghouse for evaluation which would be responsible for the generation of evaluation guidelines, selection of evaluators, conduct of evaluations, synthesis of evaluation data, and reporting of results in useful form to NSF. An organization such as the MREP could function in this way.

The generation of guidelines is necessary to standardize procedures for ease of interpreting evaluation reports and ensuring minimum requirements for evaluation. Since competent evaluators are to conduct the actual evaluations, the guidelines cannot be restrictive but must allow the evaluator freedom to utilize his talents in situations in which the guidelines are inappropriate or inadequate. The guidelines should contain minimum standards for evaluation, criteria for a good evaluation, procedures to be followed, prototypic instruments, prototypic data summaries, report format, and budget guidelines.

The selection of evaluators will be made by the clearinghouse agency. The most efficient means is probably to define regions of the country and to identify persons or agencies within the regions who would be responsible for all evaluations within the region. Regional laboratories, university organizations, and research corporations are the most likely agencies to be utilized. Each party would contract directly with NSF for the evaluations within the defined region, but would report to the central clearinghouse, which would have final authority on performance specifications. This results in decentralized budgeting but centralized control.

Each regional agency, considered competent, would have the option of performing evaluations itself or subcontracting some evaluations to identified competent evaluators within the region. This would be left to the authority of each regional agency, which is a broker for evaluation.

Each agency or broker is responsible for all types of projects (leadership, systems, training) funded in fiscal year 197 . Size of project and location within region will dictate the allocations of local resources.

The clearinghouse functions of the central evaluation agency will include collecting all evaluation reports, synthesizing the reports and analyzing common data across projects and providing reports to NSF on individual projects, types of projects, other research data of interest, and on the overall implementation effort.

c. Dissemination Plans

Subsequent to the conference, a series of papers will be prepared by the conference participants which will recommend specific courses of action (studies) for assessing the impact of NSF-supported curricula. These papers will be submitted to appropriate professional science educationally oriented journals to stimulate action on the part of science education researchers. Some expected topics for these articles include the following:

1. Changes in teacher education procedures stimulated by NSF curriculum development.
2. An analysis of textbook changes in science during the past decade.
3. The role of evolution in assessing the impact of national curriculum projects.
4. Continuous monitoring of course materials usage on a national and regional scale.
5. Reviews of existing information in the impact of NSF on science curriculum development and implementation.
6. How classroom teachers might cooperate in research studies relating to NSF impact.
7. Utilization of research and development information to modify classroom procedures.
8. General reviews on all the facets of science and mathematics curriculum development touched by NSF input.
9. Suggested possible studies on the changes that have occurred in institutions and programs from NSF's impact.
10. Suggested studies on the resultant learnings by students, teachers and the general populace.
11. Suggested studies on the actual use and modified uses of NSF stimulated curricular materials.
12. Possible curriculum (in broadest sense) analysis studies on science and mathematics materials.
13. The possible meanings of the term "impact" on science and mathematics curriculum development and implementation.
14. Evaluation and its importance in "impact" studies.
15. Effectiveness of dissemination, implementation and evaluation efforts related to NSF curricular development.

To carry out such dissemination and to insure that a broad spectrum audience is reached by the "impact" articles in the various professional journals, each participant accepted the responsibility to try and write for or to see that such an article was submitted to, each of the following journals:

1. Science and Children - Alice Moses
2. The Science Teacher - Dave Lockard
3. Journal of College Science Teaching - Les Paldy
4. The American Biology Teacher - Paul Hurd
5. Journal of Research in Science Teaching - Wayne Welch
6. Journal of Chemical Education - Bob Howe
7. School Science and Mathematics - Ron Townsend
8. The Mathematics Teacher - Jim Wailes
9. Journal of Geological Education - Dave Lockard
10. The Physics Teacher - Les Paldy
11. Science Education - Bob Howe and/or Wayne Welch
12. The Arithmetic Teacher - Jim Wailes and/or Alice Moses
13. Science and Science Education News - Dave Lockard and/or Wayne Welch
14. Journal of Social Studies Education - Jim Wailes
15. SSEC Newsletter - Jim Wailes and/or Bob Howe
16. NSSA Newsletter -
17. State science and mathematics teachers organizations journals -

As the articles are submitted to the journal editors, they will also be forwarded to the conference director to become a part of the Appendix of the final NSF conference report, due in August, 1975.

IV. RECOMMENDATIONS TO THE NATIONAL SCIENCE FOUNDATION

1. That NSF continue their support of science, mathematics and social studies curriculum development and implementation activities. Since no other educational research and development arm exists in NSF it is crucial that this be continued by the Materials and Instruction Development Section (MIDS). This should be done while staying aware of:
 - A. Changing school goals and needs
 - B. Integration of the sciences
 - C. Modular and short school course trends
2. That NSF develop an increased evaluation capacity. Specific actions should include:
 - A. Employment of evaluation specialists inside the Foundation
 - B. Employment of evaluation specialists out in the field
 - C. Development of self-instructional evaluation modules
 - D. Requirement of evaluation in all NSF-funded proposals (8-10% of each grant)
 - E. Support work on the improvement of evaluation methodology
 - F. Support evaluation workshops
3. That NSF develop and adopt improved dissemination mechanisms on curriculum developments, research, implementation and evaluation. This should be done through support of:
 - A. Information clearinghouse-type operations
 - B. Informational workshops and/or institutes
 - C. Newsletter development and distribution
 - D. Research on dissemination models
 - E. Curriculum analysis studies (content, materials, methodologies, domains, values, etc.) to aid school decision-makers
 - F. Studies of curriculum selection committee processes
 - G. Development of plans for dissemination of findings
4. That NSF publish a compendium of project final standardized reports and feedback NSF reactions to the projects through the project directors. The project final standardized reports might cover research, development, dissemination, and evaluation. Basically they should answer these questions:
 - A. What were you trying to do?
 - B. What did you accomplish?
 - C. Why do you think that? and/or How do you know?
5. That NSF carry out research studies on "impact" such as those suggested and discussed in section III-C (page 44) of this report.

SELECTED BIBLIOGRAPHY

- Anderson, Ronald E. Research Review Series - Science, Paper 10, Review of Research in Science Education for the Year 1971. Columbus, Ohio: ERIC Information Analysis Center, Ohio State University, April 1973.
- Balzer, A. LeVon, Thomas P. Evans, and Patricia E. Blosser. A Review of Research on Teacher Behavior. Columbus, Ohio: ERIC Information Analysis Center, Ohio State University, December 1973.
- Computers in Undergraduate Education: Mathematics, Physics, Statistics and Chemistry. College Park, Maryland: 1967.
- Howe, Robert W. "Impact of NSF Sponsored Programs on Elementary and Secondary School Programs, Teachers, and Students." 1974. (Mimeographed.)
- Koran, John J. Jr. Research Review Series - Science, Paper 8, A Summary of Research in Science Education for the Years of 1968-69 College Level Science. Columbus, Ohio: ERIC Information Analysis Center, Ohio State University, August 1972.
- Lockard, J. David (ed.). Eighth Report of the International Clearinghouse on Science and Mathematics Curricular Developments 1972. College Park, Maryland: Science Teaching Center, 1972.
- Lockard, J. David. "Examples of Change in Science Curricula." 1974. (Mimeographed.)
- Novak, Joseph D. A Summary of Research in Science Education for 1972. Columbus, Ohio: ERIC Information Analysis Center, Ohio State University, December 1973.
- Schlessinger, Fred R., Robert W. Howe, Arthur L. White, Long F. Chen, James H. Baker, and Ellen C. Buckeridge. A Survey of Science Teaching in Public Schools of the United States (1971). Volume 1 - Secondary Schools. Columbus, Ohio: ERIC Information Analysis Center, Ohio State University.
- Trowbridge, Leslie W. Research Review Series - Science, Paper 9, A Summary of Research in Elementary, Secondary and College Levels of Science Education for 1970. Columbus, Ohio: ERIC Information Analysis Center, Ohio State University, September 1972.
- Wailles, James R. History and Development of National Science Foundation Elementary Institutes 1959-1967. Boulder, Colorado: University of Colorado, December 1968.
- Wailles, James R. "Possible Areas of NSF 'Impact'." 1974. (Mimeographed.)
- Welch, Wayne W. "Some Thoughts on the Impact of National Curriculum Projects." 1974. (Mimeographed.)

VI. APPENDICES

**Publication, Marketing, and Royalty Policies for NSF
Education Materials—Time for a New Look?**

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Last spring marked a point of sharp departure in the way in which the National Science Foundation's precollege science education budget was treated by the Congress. That in itself would have been newsworthy enough, but the discussion provoked by the issues raised in connection with handling of the precollege implementation program contributed to a Congressional controversy that may affect the vital interests of all science educators. This article will review those events and will attempt to identify some issues related to NSF involvement in the implementation of curriculum projects that merit further study by those responsible for developing long-range educational policy. To place the controversy in context, it is useful to review the way in which a curriculum project is generated, supported, and implemented by the National Science Foundation.

Curriculum Development at NSF
A typical curriculum development effort is conceived by an individual or small group of workers who identify a need for the materials and who develop a base of support for the idea within the community by exchanging correspondence with others in the field, organizing conferences and, in various ways, attempting to generate the groundswell of interest that is needed to persuade NSF that the program is worth development. It is not unusual for the initiative to come from NSF; conferences may be supported to develop ideas and identify promising approaches which will merit future funding. This preliminary developmental work and planning is followed by the submission of a preliminary proposal which is reviewed within NSF or occasionally sent to an outside reader for comments and criticism. If the ground has been prepared carefully, and if the early planning groups included luminaries in the field, NSF usually suggests that the group coordinating the effort submit a formal proposal. The formal proposal is circulated to authorities in the field for review (hence the advantage

of having well-known persons associated with the effort) and is subjected to careful examination by specialists within NSF. If the grant proposed is a small one, NSF can approve it in a routine way, but if it is for more than \$500,000, it requires the approval of the National Science Board, a 24-person policy-making arm of the Foundation, composed of distinguished scientists, corporate heads, and high-level university officials who meet in Washington periodically to review NSF policies, together with the NSF Director. In preparation for this examination, the NSF staff responsible for overseeing the proposed activity prepares an internal memorandum justifying the grant recommendation in detail. The Board reviews the recommendation and, in most cases, passes on it favorably.

Once the grant is made, the developmental effort begins in earnest: A project team is assembled at a university or nonprofit development center, drafts are produced, prototype equipment and software are prepared and used in trial situations to gather feedback which can be used to make subsequent modifications. In the jargon of the developers and the agencies, this is called "formative" evaluation, since the information gained can presumably be used to modify what happens later.

At some stage in the development of the curriculum materials, tentative contacts are made with publishers who might be expected to have an interest in handling materials of the kind being prepared and, when the project has progressed far enough for the developers to have a clear idea of what the final materials will look like, competitive proposals are solicited from companies seeking to publish and distribute the materials. While the funding agency is obviously an interested party in these negotiations, it usually does not take an active part in the process, although it must accept the eventual contract that is agreed to between the development group and the publisher. One of the key fea-

tures of these contracts is that they usually include a clause that returns a royalty to the federal government to compensate for the federal investment in the development of the material. In some cases, other arrangements are made whereby the publisher agrees to make available a fraction of profits for teacher training in the use of the materials or other activities considered to be in the national interest.

Once the project materials are being distributed by the publisher, and depending upon the enthusiasm with which they are received by users, revisions may be made and second editions prepared. It is not uncommon for curriculum development groups to be dissatisfied with the way in which the publisher markets and advertises the materials, and most of the more experienced groups have learned to attempt to include precise specifications in contracts to ensure that the publishers conform to the original intent of the developers. This is easier said than done and, as one might expect, the performance record is mixed.

If you examine the fine print in the front of the first edition of an NSF-supported science education project text, you may find a clause which reads as follows:

Except for the rights to material reserved by others, the publisher and the copyright owner hereby grant permission to domestic persons of the United States and Canada for use of this work without charge in the English language in the United States and Canada after January 1, 1976, provided that publications incorporating materials covered by these copyrights contain the original copyright notice and a statement that the publication is not endorsed by the original copyright owner. For conditions of use and permission to use materials contained herein for foreign publication or publications in other than the English language, apply to the copyright owner.

The rationale for this is that, since the federal government paid for the development of the materials, the public should have the right to use them after the publisher has had a reasonable period of time to recover his initial investment and make a profit. Usually, when you examine a later edition of a successful project work, you will find that this clause has disappeared. Instead, the later edition lists several of the original project development group as co-authors and states that copyright is held exclusively by the company, with no permission granted for free use. This procedure is one which has not received wide public scrutiny within the science

education community or by the Congress, and is consequently not well understood. What is its rationale?

From the government's point of view, it has seemed reasonable to require free use of the original materials that are developed with public funds once the publisher has had a chance to recover his investment. Obviously, no profit-making organization is going to tool up to produce materials that become "fair game" immediately; a 4-8 year period appears to have been chosen as a reasonable compromise in an attempt to protect the public interest on the one hand while providing the publisher with a profit incentive on the other. Later editions of the work are usually supported solely by the publisher, with the major share of the revision being handled by a core of workers from the senior staff of the group that did the original work, who may receive an advance payment, royalties, or both for their efforts, depending upon the kind of contract that they negotiate. The final effort is protected by the publisher's copyright. Again, from the government's point of view, this seems to be reasonable; the profit incentive is necessary if the original writers are to be persuaded to spend any substantial amount of time revising the work, and the publisher has an incentive via the possession of the copyright to market the material. The demand for the material is set by the usual market conditions, and the public continues to enjoy the opportunity to purchase materials of high quality. Critics, on the other hand, claim that such arrangements do not adequately protect the rights of the public since the later edition, although it may have been substantially modified, is derived from original material which was prepared with federal funds. Still another criticism is sometimes heard from members of the original project staff who did not participate in the final revision and hence do not enjoy royalty arrangements even though, in their estimation, the final work reflects their original contributions as well as those of the revisers. We will turn to these issues again, later in this article.

School Implementation Once a new precollege curriculum project has been marketed, NSF supports programs that seek to install the materials in school settings across the nation under the general heading of "Instructional Improvement Implementation." At the precollege level, three categories of pro-

grams are considered for support. "Teacher-centered" programs resemble summer institutes in many ways, although the traditional stress upon pure subject matter has been offset to some extent by a concentration on the installation of a particular curriculum project or innovation in a school setting. Teachers may come from all over the United States to a college campus bearing a kind of "moral commitment" from their school administrations to use the materials being studied when they return. Since these commitments are implicitly hedged by the availability of funds at the local school level, they must often be token gestures on the part of participants who would certainly like to try using new materials, but who may be able to do so only in a very small way.

The next category of precollege implementation grant involves "school-centered" projects. In this type of activity, a college or university seeks to obtain an explicit commitment from a school or school system to use the materials being studied once its teachers have been trained to use them during a summer or academic-year program. Finally, leadership programs for science supervisors, college professors, and school administrators round out the NSF effort to reach a variety of audiences and to increase the number of schools in the country that are using curriculum materials of high quality.

In recent years, demands for accountability and interest in the outcomes of educational innovations have caused NSF to look harder at the results of its precollege activity. Unfortunately, results are not easy to come by. For a time, the Foundation was barely able to do more than cite publishers' sales figures when it was pressed for hard data regarding the utilization of NSF-developed materials in the nation's schools. In recent years, it has commissioned a variety of studies which sought to gather better data by polling schools directly. Even here there are difficulties, for it is well known that school reporting is notoriously untrustworthy; the fact that a school reports that it is using a curriculum project does not mean that the materials are being used in a manner that the producers of those materials would recognize. For example, if a high school uses a small part of the PSSC text without using any of the laboratory materials, is it accurate to say that it uses the PSSC course?

The precollege program of the Foun-

dation had suffered at the hands of the Office of Management and Budget planners during the Nixon administration, with impoundments being particularly severe during the 1973 fiscal year. Given the political and fiscal climate in Washington, there was really very little hope that the new administration would view the education program of the Foundation more favorably. That prediction was borne out when the administration presented its FY 1976 budget request that called for a 12 percent reduction in overall science education support from the 1975 level even though the overall NSF budget increased. When the budget was presented to the House Committee on Science and Technology early last spring, those members who consider science education to be a high-priority item in assuring a continued supply of scientific manpower and scientifically literate citizens, pressed vigorously for a restoration of science education funds and succeeded in reporting out of the Committee a bill that called for more money than the administration had requested. All this would not have been unusual, for Congressmen resonate to the interests of their constituents, and the science education community and representatives of higher education make a reasonably articulate and effective lobby. What was unusual is that the Committee hearing room provided the initial setting for a virtually unprecedented attack on the substance of a curriculum project that had been developed and implemented under the NSF aegis. Later, the debate was to move before the entire House of Representatives.

The project in question, "Man—A Course of Study," (MACOS) is an elementary school social studies program with an anthropological focus designed for use in the fifth, sixth, and seventh grades. The course was developed by a team of anthropologists and educators at the Education Development Center in Newton, Massachusetts, beginning in the early 1960s, and carries the imprimatur of the well-known educational theorist Jerome S. Bruner. It includes units dealing with the behavior of herring gulls, salmon, baboons, and humans. The theme of the course has to do with the identification of those elements of human behavior which appear to be unique to the species, and culminates in an examination of the culture and traditions of the Netsilik Eskimo tribe, a small band of nomadic hunters in Canada that has so far managed to preserve most of its

traditional customs and, in consequence, is about to vanish.

MACOS evolved more or less along the general lines of other curriculum development projects. Its development phase was completed in 1969 and cost approximately \$6.5 million. The materials, including a substantial number of 16 mm films, are marketed by Curriculum Development Associates, a small firm in Washington, D.C., and the National Science Foundation supports the usual array of implementation projects (teacher-centered, school system, and leadership) designed to publicize the existence of the materials and assist school districts that choose to use them.

The attack on MACOS was launched by Representative John B. Conlan, Republican of Arizona, and had two major thrusts. The first dealt with the substance of the project and its appropriateness for young children. Extensive testimony appears in the *Congressional Record—House* for April 9, 1975, commencing on page H 2575. The following excerpts from Representative Conlan's statement convey the general thrust of his criticism of the course itself.

Mr. Conlan: Mr. Chairman, my office and others have been inundated with outraged complaints from parents nationwide about the National Science Foundation spending more than \$7 million to promote and market a social studies course for 10-year-olds called "Man: A Course of Study."

I share their indignation. My amendment is designed to reassert congressional authority over NSF curriculum activities to stop what is shaping up as an insidious attempt to impose particular school courses and approaches to learning on local school districts—using the power and financial resources of the Federal Government to set up a network of educator lobbyists to control education throughout America.

Congress needs to stop this, and to tightly review NSF curriculum implementation activities. This is especially vital in light of the revelation when the MACOS issue came up in committee last month that, as late as March 6 of this year, neither NSF Director Guyford Stever nor any top officials of the education staff there had reviewed any of the MACOS materials or knew what was in the course, despite a 12-year NSF involvement in developing or marketing the course at taxpayers' expense.

Mr. Chairman, MACOS materials are full of references to adultery, cannibalism, killing female babies and old people, trial marriage and wife-swapping, violent murder, and other abhorrent behavior of the virtually extinct Netsilik Eskimo subculture the children study.

Communal living, elimination of the weak and elderly in society, sexual permissiveness and promiscuity, violence and other revolting behavior are recurring MACOS themes.

This is simply not the kind of material Con-

gress or any Federal agency should be promoting and marketing with taxpayers' money.

The course was designed by a team of experimental psychologists under Jerome S. Bruner and B. F. Skinner to mold children's social attitudes and beliefs along lines that set them apart and alienate them from the beliefs and moral values of their parents and local communities.

This aim of MACOS is blatantly spelled out in the course's philosophical and behavioral manifesto—a teacher's book of essays called "Man: A Course of Study Seminars for Teachers."

In this MACOS book there is a call for a radical break from traditional loyalties from self-avowed French Marxist Claude Levi-Strauss:

Ours is the only society from which we have to disentangle ourselves.

There is a justification for using children's lack of awareness and immaturity to shape new values:

Infant plasticity and prolonged immaturity provide us as humans with the opportunity to shape the development of our offspring, and in this sense "humanness" is a continuous human invention. ("Man: A Course of Study Seminars for Teachers," p. 1)

And there is a call by behavioral psychologist B. F. Skinner to use lower grade classrooms for conditioning to mold a new generation of Americans toward a repudiation of traditional values, behavior, and patriotic beliefs:

Education is the establishing of behavior which will be of advantage to the individual and to others at some future time. . . .

(R)einforcements are arranged by the educational agency for the purpose of conditioning. ("Man: A Course of Study Seminars for Teachers," p. 7)

The Conlan Amendment—Pro and Con

Even this criticism would not have been enough to alarm NSF officials or other representatives who did not share Mr. Conlan's philosophical reservations about the course. When one holds an office that is "recycleable" at two-year intervals, it is to be expected that the officeholder will try to demonstrate to his constituents that he is seeking to reflect their views or reiterate his own views (which got him elected in the first place) before a national forum. What did concern observers was the amendment that Mr. Conlan sought to attach to the authorizing legislation for the NSF budget.

(b) (1) No funds authorized to be appropriated to the National Science Foundation under this or any other Act shall be available to implement or market course or curriculum programs or materials unless the Committee on Science and Technology of the House of Representatives and the Committee on Labor and Public Welfare of the Senate have first been provided a complete prospectus for each

course or curriculum project proposed for such funding by the Foundation, and—

(A) the funding to implement or market such course or curriculum programs or materials has been specifically approved in an Appropriations Act; or

(B) both Houses of Congress have adopted a resolution approving such funding for implementation or marketing.

(2) For purposes of this section, a prospectus shall include—

(A) the grant application with names and institutional affiliation of applicants, justification for the implementation grant, and duration of the project;

(B) a complete description, educational objectives, and historical overview of the course or curriculum to be implemented;

(C) copies of all evaluations and recommendations concerning the implementation proposal; and

(D) the National Science Foundation budget and fiscal report, the total per-pupil cost to implement the course or curriculum, sources of other funding, and a projection of future Federal funding for the course or curriculum.

It is clear that the inclusion of this amendment in the final legislation would have changed the way in which the National Science Foundation Education Directorate would go about its business, and would constitute a precedent whose implications for the rest of the scientific community would be all too clear.

The following excerpt reveals the other facet of Mr. Conlan's criticism, one which, in many ways, is more interesting because of its implications for science education policy formulation. Here, Mr. Conlan criticizes the basic curriculum development and implementation process of NSF.

Mr. Chairman, transcending serious concerns about the particular nature of "Man: A Course of Study," my amendment is addressed to the larger and more vital issue of local school choices and decisionmaking. We Americans place a high value on local autonomy in education, and have always repudiated a national policy on education or a single national school system directed from Washington.

However, NSF activities in curriculum implementation are moving ominously in that direction. Consider these facts:

When MACOS development was completed in 1969 at a cost to taxpayers of more than \$6.5 million, more than 50 publishers were offered and refused to market the course because of its objectionable content, philosophy, and its high cost.

It is enlightening to note that these, more than 50 publishers, ordinary commercial firms of long-standing reputations, rejected the blandishments of NSF and Education Development Center, who developed MACOS, and refused to have anything to do with what they uniformly regarded as a curriculum not desired by American parents and schools.

But this adverse judgment by experienced professional publishers did not deter NSF and

EDC. They seeded Curriculum Development Associates, a small commercial publishing firm in Washington, so that a profit could be made. And NSF gave CDA a special 80-percent cut in the normal royalty required when federally developed school materials are sold commercially so MACOS would sell and undercut competition from other curriculum materials available in the private sector.

In ordinary textbook trade channels, 15 percent royalties are paid to authors or developers of published materials. Since NSF gave most of the money for development of MACOS, one would expect the Foundation to demand the ordinary return on its efforts, should there be a marketing of the results of such efforts.

In the particular case of MACOS, however, NSF permitted only a 3-percent royalty return to the Government—one-fifth the customary amount—and has in turn received from EDC at last report less than 10 percent of that greatly discounted royalty.

Of the enormous sales revenues generated by NSF for CDA, a mere \$5,339 in royalties has been returned to NSF. At the same time, NSF and EDC have spent more than \$2 million in direct marketing and promotion of MACOS for its commercial publisher.

This means that NSF has given millions to a small group of closely related individuals in order to enable them to turn a profit by undercutting competition and virtually forcing an undesirable curriculum on parents and educators across the country. The intentions of NSF—to insure a profit on an NSF project to a particular group of friends and to brutally kill off any possible commercial, educational, or parental competition—are amply demonstrated by the extraordinary royalty arrangements made with EDC and CDA for the sale of MACOS materials.

Mr. Chairman, NSF and Education Development Center are now embarked on a further multimillion dollar effort, unbeknown to Congress, to establish a larger educator network to implement other jointly developed social studies programs. Congress must stop this insidious invasion of local autonomy in education, which it can do with this amendment.

Despite assurances to Congress that all funding for such activities had been suspended to allow a thorough review of NSF curriculum policies, NSF is moving right ahead to promote and market a sequel to MACOS for high schools called "Exploring Human Nature," a more sophisticated behavior and social value modification course, and other programs for schools.

A lengthy Education Development Center grant proposal, approved and funded by NSF on January 15, graphically documents the situation we face. The prospectus outlines "establishment of a network that will initially create and then sustain linkages between existing educational institutions" to disseminate certain social studies courses for use from kindergarten through 12th grade.

The EDC prospectus, approved by NSF as grant No. PES75-01635, outlines a series of national and regional conferences and workshops to implement these courses:

In addition, the EDC promotion plan outlined in the PES75-01635 grant prospectus approved by NSF also requires each university/

school district team in the EDC educator network to apply for yearly NSF grants for their own activities over an indefinite time to support the promotional and marketing goals for EDC social science curricula.

Mr. Chairman, I cannot imagine a more dangerous plan for a federally-backed takeover of American education. This is ultimately what the MACOS controversy and out-of-hand NSF curriculum implementation activities are all about.

We must reassert effective congressional authority over all NSF activities in the area of developing and promoting school materials. My amendment, patterned after the existing requirement that all proposed Office of Education regulations be reviewed and approved by Congress before they are implemented, is a necessary first step in that effort.

Mr. Chairman, what my amendment does is to not get into the areas pro or con on this material, although this material, I think, is repugnant to me and to most of us, although to some in this body it is not. It is part of that philosophical approach that wants to reform human nature from a behavioral program rather than along classic Judeo-Christian lines.

What my amendment does is say that the implementation of the marketing of any programs shall not be done by NSF unless the Appropriations Committee specifically grants them money to do that, or unless they come to our authorizing committees and spell out exactly what the program is for an approval by this body as to whether they should go into commercial marketing of this on a statewide—not statewide, but nationwide—marketing network that they have already started within certain elements of the educational community.

Several rebuttal statements were made by members of the House who did not share Mr. Conlan's view of the MACOS program: James Symington, Chairman of the House Subcommittee on Science, Research and Technology argued explicitly for the control of school activities by local authorities, and spoke against the amendment. He also argued the merits of the MACOS materials:

What the amendment does is to make of the Committee on Science and Technology and the Committee on Labor and Public Welfare of the Senate a joint committee of censorship to determine the validity, the usefulness, the propriety of the curriculums of educational programs developed by the National Science Foundation.

Look at what it says. It says that there shall not be any funding to implement or market such courses of curriculum until specifically approved in an appropriation act or when both Houses of Congress have adopted a resolution approving such funding.

Mr. Chairman, the National Science Foundation was mandated by Congress to develop educational programs in an innovative way and not simply to develop them and put them on the shelf but to make them available to the school boards and the school districts of the country, not to ram them down their throats, but just to show them to them.

There is no more democratic institution in

the country than the school board. If the people are dissatisfied with the manner in which the school board does its work, there is a very easy way to take care of that, and that is to remove the school board and get another one.

Hundreds of school boards and hundreds of schools are using this particular program known as MACOS, and we have testimonials, as thick as those of the gentleman from Arizona, on behalf of that program of education as one which does acquaint youngsters with social conditions that are characteristic of tribal life. I must say, with all due respect to our society, our civilization, the Eskimos are not an evil people. They are a good people. They live in certain ways because conditions exist that have caused them over the centuries to adopt certain forms of life.

What this program attempts to do is to acquaint youngsters with some of the basic tenets of the organizational aspects of Eskimo life. The time for know-nothingism has long since passed. I cannot think that we will cross the threshold into our Bicentennial Year with the idea that America is turning inward intellectually, academically, tradewise, and in every other way.

In addition to arguing for the merits of the MACOS materials, Representative Charles A. Mosher, Republican of Ohio, ranking minority member of the House Subcommittee on Science, Research and Technology, argued against the amendment on the grounds that it would require the Congress to establish cumbersome review machinery:

However, Mr. Chairman, the nature of MACOS, this one anthropological program, is not the issue before us. The issue before us is the amendment offered by the gentleman from Arizona (Mr. CONLAN).

I suggest that that amendment would put a horrendous burden on the congressional committees and on the Congress itself. It would require that we have oversight responsibility of each particular proposal. We in the Congress would have to view and approve each particular proposal.

There were more than 600 proposals last year, 300 of which were approved. I cannot imagine Congress taking on that burden.

Further examination of the *Congressional Record* shows that many other Representatives spoke for or against the amendment, but the major themes of the statements did not vary very much. Proponents argued that the National Science Foundation had no business in "marketing" curriculum materials to school districts at taxpayer expense and in direct competition with commercial book publishers. Those opposed claimed that the choice of curriculum materials should be left up to local authorities and that the National Science Foundation should be free to support the development of materials that it regarded as being worth-

while. Finally, by a close vote of 215 to 196, the Conlan amendment was defeated. Another amendment offered by Representative Myers of Pennsylvania that would have prohibited the use of federal funds to implement any curriculum project unless public notice was first given to the community involved and all materials made available for public inspection was defeated 341 to 68, with the most persuasive argument being the obvious one having to do with the inadvisability of having the Congress involved in local school affairs to the extent that would be required by the sense of the amendment.

In Retrospect As one looks back over the events of last spring, it is too easy to shrug off these episodes as nothing more than politically motivated attempts of Congressmen to demonstrate to their constituencies that they are hot on the trails of fuzzy-minded academics who are prone to spend taxpayers' dollars on projects that will have little social pay-off. I suggest that this is a mistake, and that the issues are really much deeper, having to do with the need of the public and the Congress to develop a much more profound understanding of the role of basic research in the scientific enterprise, and of the need for working scientists and science educators to understand that it is *appropriate* for the Congress and for other elected government officials to make the final decisions as to what society shall do and to take final responsibility for those decisions. It comes down to our answering the question, "How can Congress and the people learn?" It has long been appreciated that politicians need scientific advice, but it is not always acknowledged that scientists need political advice and support if their work is to flourish in a social context.

Areas for Study Rather than attempting to address the general problem presented by the scientific-political interaction here, it may be more useful for science educators to consider some of the issues raised in connection with the MACOS controversy to attempt to isolate areas that may warrant further study. We can begin by looking more critically at the various stages of the development and implementation of the curriculum effort that is supported by NSF.

It is clear that the existing mechanism which utilizes peer review procedures to

assess the merit and probable impact of the project proposed will continue to be a necessary component of any system that is to work well. Trained scientists and educators constitute a powerful team when they combine their insights into the structure of the discipline and the nature of the pedagogical process to make an assessment of the merit of a proposal. It is inconceivable that the system would work without peer review. But is this kind of review *sufficient*? One can conceive of the possibility that a group preparing a new curriculum development project might routinely be expected to prepare an "educational impact statement" that would attempt to assess how the materials that they are proposing would be received by various constituencies within the community. If such statements were required, it might be desirable to widen the scope of the peer review panels that customarily review these proposals to include community leaders and others with distinguished records in public affairs who might be expected to have insights into the way in which citizens are likely to react to the materials that are being proposed for development. Surely, a Congress that is asked to support these ventures will react favorably to the idea that projects for which they are asked to bear ultimate funding responsibility have withstood the scrutiny of generalists who have no particular axes to grind. No responsible science educator could object to receiving input and advice from representatives of the larger community that will be expected to pay for the inclusion of new materials in the school curriculum. I suggest that a modest study might be made of the feasibility of this plan and, if the initial reaction is favorable, that attempts be made to implement it immediately.

At the next level of project development, it is hard to see how things might be done differently. One relies upon the recommendations of reviewers and the judgment of those within NSF to make wise decisions about the support of proposals, and one expects groups that receive grants to do their best to achieve the objectives that they have set for themselves.

Next, consider the problem described earlier that is related to the link between federal support for the developmental effort and the commercial marketing of the materials. The problem is clearly complex and does not lend itself to sim-

ple solutions. It is important to remember that U.S. copyright law derives directly from Section 8 of the United States Constitution which specifies that "the Congress shall have power to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." The intent of the Constitution here is to promote progress by providing an incentive to authors to publish. Hence, the existing NSF policy that makes it possible for a publisher to make a profit from work derived from material that was originally financed with federal money is not necessarily unwise or inimical to the public interest. What would seem to be important here is that the public's interest be protected in the actual negotiation of contracts so that it is not possible for a publisher or group of individuals to negotiate an arrangement that is unreasonably favorable. For example, it is obviously possible for such contracts to include clauses requiring that a larger fraction of profits from later editions be reserved for teacher training or related educational activities, or for profit margins on particular products to be limited in much the way that utility company profits are regulated in an effort to keep costs down. Perhaps, in view of the fact that the publishers pay no author's advances, four years is too long a time to wait for free use. Just what are the profit margins? What special accounting practices might be required to ensure that the economics of NSF-developed curriculum materials can be kept in sight and not lost in the general corporate ledger?

Readers interested in a wide-ranging discussion of copyright and public domain policy should read reference [1] and the brisk exchange of letters commenting on the article in reference [2]. The publisher's point of view is particularly well represented here.

Technological Alternatives to Corporate Publication Perhaps it would be useful to consider some radically different ways of placing federally sponsored science education materials into the hands of potential users. For example, although it may not be widely appreciated, the U.S. Government Printing Office is a major publisher by anyone's standards. Many agencies take advantage of its capabilities to make low-cost documents available to the public. The U.S. Department of Agriculture has, for

many years, made available a wide range of excellent publications at prices that are substantially lower than one would expect to pay for commercial versions of the same material. Why cannot NSF do the same? What do the numbers look like?

Innovations in printing technologies have also increased the range of possibilities. Most modern typesetting involves the use of computer tapes which contain all the text material together with coded instructions which control type size, heading information, and related matters. Studies could be made of the feasibility of providing such tapes, photographic plates, or the next generation of such devices directly to cities, states, or educational units that cannot afford to buy new materials, but that might take advantage of local printing presses that could produce materials less expensively than their larger commercial counterparts. This policy would recognize the existing situation in which schools reproduce copyrighted materials in clear violation of the law. For example, many school districts routinely videotape commercial television programs for rebroadcast to classes, and make "ditto" copies of large portions of texts.

Social Incentives Many of the old-line publishing houses are being taken over by multinational conglomerates that do not hesitate to do whatever must be done to increase profits. It is not uncommon, for example, for companies like Holt, Rinehart and Winston, Inc., a CBS subsidiary, to arrange to have the typesetting for a text done in Asia to take advantage of cheap foreign labor. Is it in the public interest for this to be done with a federally supported effort? Is it done? How much does it cost the nation in trade balance problems and in uncollected taxes? How many jobs are involved? Without making any value judgments about the social utility of giant corporations and the long-term effects upon the American economy of policies which make it extremely difficult for small businesses to compete in the market place, it is possible to believe that a study might reveal that there are economic advantages that could be realized by small educational units that sought to contract for the printing of their own texts using "masters" that are provided at low cost from the federal government or from intermediate institutions that contract to provide this service. Consider

now a local school board might react to a plan that made it possible for the board to award a contract to a small business in its own community to produce instructional material for use in its own schools. One can argue that local printers may not have the four-color press capabilities of the large printers, but when many schools simply cannot adopt curriculum innovations that are priced beyond their means, it is not unreasonable to suspect that they would be willing to consider a product that was not quite as glossy but that contained substantially the same information.

It is possible that the same principles could be extended to the production of hardware for curriculum projects. Molds, dies, and other items might be made available at low cost to educational institutions or small businesses that sought to serve their own communities.

The counterargument will be made that curriculum materials must be marketed aggressively if they are to be adopted by schools. It will be claimed that only large publishing houses are in a position to conduct campaigns to keep a project in public view and confer upon it the status and mystique that will persuade a wavering potential user to decide to buy the materials. In any case, these matters are susceptible to detailed economic analysis and warrant further study by those responsible for the formulation of educational policy.

A Congressional Capability in Science Education Policy It is clear that there is a practical strain in American culture that some may choose to regard as anti-intellectual. On the other hand, there will be others with sufficient vision to understand that it is not inappropriate for congressmen to want to know why they should support research activities and curriculum development efforts that seem far removed from the immediate needs (or, just as important, what they perceive to be the immediate needs) of their constituents. Most legislators understand that it is necessary for the federal government to support R & D efforts that are too expensive for the states to manage. The scientific and the educational communities may have to continue to rely heavily on spokesmen in Congress who understand the need for basic research and the limitations of the scientific enterprise as well as its potential to make contributions to the improvement of the human condition. Perhaps a more systematic effort focusing

on science education would be valuable. Several of the major scientific societies have seen fit to establish Congressional Fellowship programs that make it possible for scientists to spend one or two years working with a congressman or serving on a committee staff to increase the congressional legislative capability in the fields of science and technology. It would not be difficult for NSF to support a small study that would explore the feasibility of having the science education groups band together to do the same thing, making several persons available to the Congress who had a substantial grasp of the problems that the nation is confronting in the field of science education to serve as advisers on legislative matters relating to curriculum development and implementation.

Self-Study, Program Evaluation, and Management

Finally, it might be useful for NSF to conduct a self-study to examine the effects of the implementation policies that have been in effect since 1973, and that have tended to give emphasis to the support of programs to implement curriculum projects that were originally developed with NSF funds. To be sure, Foundation guidelines point out that any curriculum project is eligible for implementation activity support, subject only to the condition that it be judged to be of high quality. Nevertheless, it would be useful to try to understand whether or not potentially innovative activities have been discouraged because their proponents did not think that they would be given equitable consideration. In particular, it would be useful to know whether the lack of emphasis on pure subject-matter training is discouraging academic scientists from submitting proposals. It would be a relatively simple matter for the Foundation to contract with a group to study the grant distribution patterns of recent years and contrast them with the patterns of an earlier period. Follow-up studies could be made to analyze changes in patterns of awards, if any exist.

Common Sense Clinical, in-depth studies are time consuming and relatively expensive, but they are needed to complement the traditional shotgun survey of thousands of schools with the use of questionnaires and other "instruments." Education is a complex process and its trends are not simple to identify. Anyone who believes that school patterns are going to change sharply as a result of the introduction of behaviorist terminology, the adoption of managerial strategies

that rely heavily upon "PERT" methods, critical path analyses, and other techniques that are reputedly "cost effective" has overlooked the fact that those methods were used extensively by the same team that brought us Vietnam, huge defense-cost overruns, corporate disasters that required federal surgery, unprecedented inflation, and a business recession.

Surely, quasi-analytical techniques are not to be ignored when considering science education problems, but let us not delude ourselves, either. Despite the widespread adoption by schools of the use of behavioral objectives on the one hand, and planned program budgeting on the other, the College Board scores have fallen and the National Assessment of Educational Progress has revealed that American students are doing less well in science than they used to. One wishes that the recognition of these facts would produce a little more humility on the part of those who claim to have grand "managerial" and "scientific" solutions for problems associated with the development of a scientifically literate population. The problems are very large and progress will only be made toward their solution if hard work and common sense win out in the competition with jargon, superficial analyses, and cosmetic programs that gloss over the social, economic, and political issues involved. The National Science Foundation would do well to undertake studies of the kind that have been suggested here if it seeks to demonstrate to the Congress and the people it serves that it is attempting to be responsive to problems that any sensible person would recognize as significant. One does not have to accept Representative Conlan's arguments, but it might be extremely unwise to ignore the sentiment behind them and the resonant chord that they evoked in the House of Representatives. ■

References

1. Henry, Nicholas L. "Copyright: Its Adequacy in Technological Societies." *Science* 186:993; December 13, 1974.
2. Benjamin, Curtis, et al. "Copyright and Public Domain Policy." *Science* 188:866; May 30, 1975.

AUTHOR'S NOTE:

As this article goes to press in mid-July, the House of Representatives Appropriations Bill for the National Science Foundation explicitly prohibits the expenditure of funds for the Foundation's Pre-College Instructional Improvement Implementation Program, primarily as a

result of the debate over the merits of the MACOS program and the propriety of NSF involvement in efforts to install new science curriculum materials and teaching practices in schools. It is not clear at this time whether or not funds for this purpose will be restored, despite the intervention of various professional organizations. The issue will be decided at a House-Senate conference that should be held during the next week or ten days.

The National Science Board, NSF's policy-making body, passed several resolutions at its June 20 meeting that bear on the matter. We summarize them here and include parenthetical interpretations of their meaning.

1. NSF should carry out a broad-based analysis of future needs in science education. [Curriculum materials should not be developed and implemented merely because a small group of individuals believe that it is important to do so.]

2. NSF should ensure competitive selection of project developers addressing these needs. [Once genuine needs are identified, competitive proposals should be solicited from groups which believe they can develop appropriate materials to meet those needs.]

3. NSF should develop many "alternatives" and establish administrative procedures in the implementation stage that will avoid any appearance of indoctrination or coercion. [The Foundation must not even appear to be in the business of establishing a single federal standard for education in the natural and social sciences.]

In our pluralistic governmental system, many groups contribute to the planning for the NSF science education appropriations bill. The National Science Board establishes broad Foundation policy, while the executive branch attempts to determine what an optimum level of support would be, taking into account national needs, competing claims for resources, and political goals of the President. In turn, the Congress attempts to keep its constituents satisfied by doing what it can to support those programs which have the most political impact. This unusual debate over the Foundation's vote in science education is sure to have repercussions, not only for precollege programs, but for higher education as well. Regardless of the outcome of the debate, NSF policies and programs will necessarily be modified to take into account the sharp shift in the political wind from the Capitol.

Article for
SCHOOL SCIENCE AND MATHEMATICS JOURNAL
Submitted by
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Assessing NSF Impact in the Arena

A small group of science educators were summoned to a conference at the University of Maryland in August, 1974 for two days of concentrated brainstorming on possible studies to evaluate the impact of the National Science Foundation on science instruction in the United States. The eight participants came from diverse backgrounds and professional positions with a variety of points of view. With NSF representatives as observers, the conference interactions produced a wide base of recommended "impact studies" which could serve as guidelines to assessing some of the more cogent effects that the Foundation has had on American science education over the past several years. Viewed from the vantage points occupied by the different participants articles containing suggestions for studies will appear in several professional journals, as well as in a final composite report to the National Science Foundation.

Just as administrators, planners, reporters and equipment developers must interact with coaches and athletes to satisfy the paying customers in the athletic arena, so those who make the broad decisions and assessments concerning curricular projects must interact with teachers, students and parental customers in the arena of the classroom. As one would expect, many of the NSF impact studies cited by conference participants, such as directors of NSF-sponsored institutes, national curriculum developers, presidents of national organizations, journal editors, teacher educators, etc., often were more global in scope than those suggested by elementary and high school practitioners. (Howe, 1974)(Welch, 1974).

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The overlapping areas between the global recommendations and local priorities which evolved from the conference may prove to be the most viable points at which to attack the very complex problem of NSF impact. Working in areas of intersection between global and local concerns would not only increase the relevance of impact studies in the crucible of real classroom needs, but also would provide a practical vehicle for re-uniting two groups of educators whose professional interactions were instrumental in the development and implementation of NSF curriculum projects of the last decade.

The theoreticians, educational researchers and curriculum developers must, once again, meet on a colleague basis with the science teachers and practitioners in a common effort to assess their previous curricular handwork. This is not to suggest that pertinent science education research studies have not been conducted (Novak, 1973), but rather to point to the lack of resultant classroom changes, or even teacher awareness of these studies. Doctoral studies on curricular effects in science education abound (Knight and Small, 1975), but the final resting place of the results of such studies is usually on the shelf inside the covers of a dissertation, rather than adding to a bank of systematic data in a language or form which is understandable and useful in most elementary and secondary schools.

Few of even the most outstanding science teachers have the background or the expertise to design and conduct educational research studies, even in their own classrooms. They do, however, understand the daily activities of science classrooms filled with today's young people, and the curricular problems these present. The workload of classroom science teachers is increasing as lower budgets force larger classes and more contact hours. As

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survival in the day-to-day instructional setting takes precedence over evaluation of curricular effectiveness, research efforts to improve student learning may fall farther from the teacher's grasp. Without readily available resource people working cooperatively with them on research, curriculum development, evaluation and new technologies, the veteran teachers may become complacent in familiar routines, and thus be virtually impregnable to future impacts from NSF or other change agencies.

A consortium of classroom science teachers, university faculty and representatives from state departments of education in a geographical region could provide a basis for changing research techniques and reporting so that communication of the findings would be translatable directly into instructional activities and future curricular needs. This type of cooperative effort might initiate heretofore unthought of objectives, instructional procedures and evaluation techniques. Through such an interactive network studies such as was conducted on dissemination procedures for one curriculum project in Florida (Westmeyer, 1967) could be replicated for other projects concerning NSF impact on teachers. Both pre-service and in-service teacher programs could move closer to the "three R's of teacher education" proposed in a panel report on the future of secondary school teacher education (Townsend, 1974):

1. Emphasize the relevance of necessary knowledge and skills proposed by professors of education within the context of elementary and secondary science classrooms.
2. Enhance the resources (human, material and service) available to schools by closer cooperation between college of education faculties and the schools from which they receive their clientele and whom they serve.

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3. Increase the potential for educational research that might have immediate impact upon classroom instruction rather than dissipate in the upper atmosphere of academic debate.

Through a network of interacting professionals (teachers, administrators, researchers and curriculum developers) the classroom teacher could become part of one of several regional consortia established to study areas of impact of NSF curriculum materials as well as to participate in needs assessment studies for future efforts.

Using the global areas recommended for NSF impact studies to define criteria measures, the degree of impingement of the NSF programs on each or any of the local elements could be assessed. Composites of this information from several regional assessments would yield a more realistic picture of the impact of NSF on science instruction across the United States than can now be gleaned from the many independent doctoral studies or even the studies conducted by the somewhat isolated researchers, who have only occasional contact with the classroom science teachers.

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Global areas for
NSF impact studies

1. Dissemination and awareness
2. Usage of NSF-support products
3. Extension and modification of NSF projects
4. Learning and application
5. Instructional styles and delivery systems
6. Change in systems, attitudes or procedures effected by NSF supported programs

Local areas that NSF
may have influenced

1. Materials:
 - Texts
 - Tests
 - Media
 - Facilities
 - Equipment
2. People:
 - Students
 - Teachers
 - Teacher educators
 - Counselors
 - Administrators
 - Parents
 - Graduates
3. Institutions and Organizations:
 - School systems
 - Colleges and universities
 - State departments of education
 - Professional societies
 - Publishers
 - Equipment manufacturers

Regional consortia composed of science teachers, supervisors, university based science educators and state science supervisors could be developed to conduct realistic NSF impact studies. These consortia could also serve as communication networks to compile, analyze and disseminate research results in a form useful to decision makers at the school and classroom levels. Such consortia, once established, might conduct needs assessments for future investigations into such areas as: 1) changes in institutional structures, 2) changes in programs, 3) low teacher turnover, 4) shrinking student enrollment, 5) collective bargaining trends, 6) new educational and research technology, 7) alternative schools and 8) increased community involvement in educational procedures.

● editorial

NSF PROGRAMS . . . WHAT IMPACT?

The information contained in this editorial was drawn from an NSF Impact Evaluation Conference at the University of Maryland on August 8 and 9, 1974.

Almost a billion dollars have been spent for the development of curriculum materials and teacher improvement projects in science, mathematics, and social sciences by the National Science Foundation since 1956.

Have these funds been well spent?

What evidence do we have to show how these expenditures have helped children in the classroom?

What changes have taken place in teacher competencies and attitudes toward teaching?

Are the materials being developed superior to those previously developed?

These and numerous other questions have been raised over the past several years by staff members of the Foundation, the Congress, educators, and other interested parties. The government agency itself is most interested in obtaining answers to questions about what the impact of the NSF-funded programs has been over the years.

Unfortunately, during the development of many of the new programs, little was done on evaluation procedures and outcomes. Many educators just assumed that the "new programs" were superior to the already existing programs and practices. Because of federal funding and the large numbers of scientists, psychologists, and teachers involved in the new curriculum developments, the assumption of superiority had a great deal of intuitive appeal.

However, the assumption was based upon subjective opinion and the apparent face validity of the materials produced. Some empirical data gathered through careful use of experimental research seemed to be needed before objective decisions about the educational worth of a program were made.

Initially, the Education Directorate of the National Science Foundation was established to improve science education in the United States. This assistance took two forms: to upgrade the subject matter competence of teachers and to fund the preparation of curriculum materials for use in the schools. The customary procedure was to make grants to colleges and universities, which submitted proposals for programs for either of the above purposes. Most of the first funding went into programs designed for secondary science, mathematics, and social science teachers.

Today, the support is in three avenues: School System Projects, Teacher-Centered Projects, and Leadership Specialist Projects. Each of these projects is now carried out under the auspices of the Pre-College Instructional Improvement Implementation (III) Section of the National Science Foundation. The emphasis now appears to be concerned with the implementation of curricular programs that have been and are being developed with funding from the Pre-College Materials and Instruction Development Section of the NSF. This section supports groups of curriculum developers in the writing of textbooks, laboratory guides, resource materials for teachers, supplementary materials for students, equipment development, films, and educational research (which has just been added in the past few years).

It now appears that those educators "on the firing line"—those working with students in the schools—must answer the challenge and provide input necessary to help determine just what the impact of this large, federally funded program has been over the years. Professionals in the area—classroom teachers, administrators, science educators, scientists—and others interested in the education of children are encouraged to look seriously at this problem concerning the utilization of federally funded programs.

J.R.W.

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BOOK REVIEW

Judith Worrell and C. Michael Nelson,
Managing Instructional Problems: A Case Study Workbook. New York: McGraw-Hill Book Company, 1974. 318 pp. \$4.95.

This little volume should make a valuable contribution to the field of teacher training, especially with regard to the area of behavioral analysis. According to the authors,

... our major emphasis is on behaviorally based decision-making processes and intervention strategies, including educational assessment and diagnostic programming, physical structuring, changes in administrative arrangements, developing home-school program, counseling, and behavior modification. This emphasis is both practical and action-oriented; it presents situations and alternative strategies of framework consistent with the problems likely to confront you as a teacher. (p.xii)

There is no doubt that the book carries out these instructional goals utilizing a workbook format which should help motivate the student by active participation. The first two chapters of the text are devoted to a survey of the basic principles of behavior modification.

The concepts are presented in a straightforward manner, with the authors developing simple as well as practical rules to establish the significance of these principles in classroom situations. The research literature is presented unobtrusively, but should convince the student that these principles have actually been tested and do indeed work.

In each of the remaining chapters, which form the workbook patterns, the students are first presented with the review of the major concepts in the problem area and then are given appropriate classroom problems to solve. The first problem in each area is usually worked out in detail as a model to the student.

(Continued on page 4)

school & university review

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UNIVERSITY OF COLORADO

Teacher Education at the University of Colorado . . .

THE SEEDS OF GREATNESS: THE COLLEGE OF EDUCATION, 1908-1940

WILLIAM E. (BUD) DAVIS

Editor's note: This article is the second of a series of five on the history of teacher education at the University of Colorado. The remainder, from 1940 to the present, is being prepared by Prof. Mehdi Nakosteen and will begin in the Spring issue of the School and University Review.

To those pioneer educators who witnessed the first quarter century in the life of the University of Colorado, it must have been an almost unbelievable period of transition. With a campus virtually hacked out of the rocky prairie and planted on a sloping mesa leading down from the rugged Flatirons, the institution at times certainly appeared to be on the verge of being swept away, not only by the physical violence of the winds roaring down from the high

country, but also by the winds of indifference.

Somehow, some way, mostly by dogged determination, it had taken roots. Buildings had been added to a once barren campus—slowly, painfully—the money for their construction as hard to come by as were prospective students to fill their halls in those early days.

Self-styled as the "head of the public school system of the state," the University openly canvassed and solicited students—promising climate, prestige, and an education to those heeding its call. They came—at first mostly from Boulder and its neighboring counties and later from the far reaches of the state. Where in the early years the State Prep School

had borne the chief burden of preparing these young men and women for college work, a strong state high school system



Dr. William E. (Bud) Davis, president of Idaho State University at Pocatello, earned bachelor and doctor's degrees at CU, where he later was alumni director, head football coach, and dean of men. His doctoral dissertation, a comprehensive history of the University of Colorado, was published in 1965 as the book *Glory Colorado!*

began to emerge and assume the responsibility.

But this responsibility became a two-way street. Because of demands from the public school system for "advanced professional training for teachers and the more serious study of educational problems," a College of Education was authorized by the Board of Regents in January 1908 as a division of the College of Liberal Arts.

Upon the organization of the College, (Continued on page 10)

Janice Arnold Wins Graduate Award

The recipient of this year's Elizabeth Wilson Award is Janice Arnold, who has completed her master's degree in elementary education at the University of Colorado and been admitted to the Ph.D. program on the Boulder Campus. She also earned the reading specialist certificate for the state of Colorado.



ARNOLD

During the work on her master's degree, Miss Arnold worked on the Migrant Program Mobile Unit, which she will continue. The past summer she spent on a research project, *Test of Concept Utilization* in the School of Education.

Miss Arnold received her bachelor's degree from the University of Massachusetts-Boston and taught one year in

the Boston school system and three years in the primary grades at Ridgecrest, Calif.

Her goal is to teach at the university level, do consultation work in reading and elementary education in public schools, and work with prospective teachers.

ELIZABETH WILSON AWARD

Graduate women students majoring in elementary education are invited to make application for financial support under provisions of the Elizabeth Wilson Award.

Requests for application materials may be made to Dean Karl Openshaw, School of Education, University of Colorado, Boulder, Colorado 80302. Applications should be completed by April 1 each year. A stu-

dent must be admitted to an elementary education graduate program at CU before the award can be granted.

The Elizabeth Wilson Award was established by Dr. and Mrs. Eugene H. Wilson as a memorial to their daughter Elizabeth Anne, a student in the elementary education program at the University 1963-65.

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BIBLIOGRAPHY

- Howe, Robert W. "Impact of NSF Sponsored Programs on Elementary and Secondary School Programs, Teachers and Students," a working paper presented at Exploratory Conference on U.S. Science Curriculum Development, University of Maryland, August, 1974.
- Knight, Carlton W., II and Small, Mary K. "A Survey of Doctoral Dissertation Research in Science and Mathematics Reported for Volumes 32 and 33 of Dissertation Abstracts Part I (Science)." School Science and Mathematics, Vol. LXXV, No. 4 (April, 1975).
- Novak, Joseph D. A Summary of Research in Science Education--1972. Ohio State University, Columbus, Ohio (December, 1973).
- Townsend, Ronald D. "Competency, Cooperation and Change," Secondary School Teacher Education: Where Are We Going? John F. Schaff and Burton E. Voss, Editors. March, 1974.
- Welch, Wayne W. "Some Thoughts on the Impact of National Curriculum Projects," a working paper presented at Exploratory Conference on U. S. Science Curriculum Development, University of Maryland, August, 1974.
- Westmeyer, Paul. A Comparison of Various Techniques for the Dissemination of a New Science Curriculum in Florida. Florida State University, Tallahassee, Florida (March, 1967).

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BIBLIOGRAPHY

- Howe, Robert W. "Impact of NSF Sponsored Programs on Elementary and Secondary School Programs, Teachers and Students," a working paper presented at Exploratory Conference on U.S. Science Curriculum Development, University of Maryland, August, 1974.
- Knight, Carlton W., II and Small, Mary K. "A Survey of Doctoral Dissertation Research in Science and Mathematics Reported for Volumes 32 and 33 of Dissertation Abstracts Part I (Science)." School Science and Mathematics, Vol. LXXV, No. 4 (April, 1975).
- Novak, Joseph D. A Summary of Research in Science Education--1972. Ohio State University, Columbus, Ohio (December, 1973).
- Townsend, Ronald D. "Competency, Cooperation and Change," Secondary School Teacher Education: Where Are We Going? John F. Schaff and Burton E. Voss, Editors. March, 1974.
- Welch, Wayne W. "Some Thoughts on the Impact of National Curriculum Projects," a working paper presented at Exploratory Conference on U. S. Science Curriculum Development, University of Maryland, August, 1974.
- Westmeyer, Paul. A Comparison of Various Techniques for the Dissemination of a New Science Curriculum in Florida. Florida State University, Tallahassee, Florida (March, 1967).

EVALUATING THE IMPACT OF NATIONAL CURRICULUM PROJECTS

by

Wayne W. Welch
University of Minnesota

Introduction

In recent months, the National Science Foundation (NSF) has been under considerable pressure to respond to critics of its curriculum development program.¹ The criticism has come from several corners, most notably from those concerned about parts of the course entitled Man--A Course of Study. Congressional concern has resulted in an internal review of the program and prompted the formation of a citizens review committee to consider the future of NSF's curriculum development program. Both groups are examining the internal procedures for awarding and monitoring grants.

While such periodic review of the internal development process is desirable, the evaluation seems incomplete without also examining the products which have accrued from this process. It is also important to note that the Foundation is nearing 20 years (1956-1976) of curriculum development. For both of these reasons, it seems particularly appropriate, at this time, to cast an evaluative glance at the national impact of this curriculum improvement effort. This product evaluation, as determined by the impact of the program on science education, is the topic of this paper.

Specifically, in this paper I consider what is presently known about the direct effects of the program and describe a number of potential secondary effects. This general discussion is preceded by a definition of terms and followed by some recommendations for future evaluation activity.

Definitions

Evaluation is the process of delineating, obtaining, and providing information which can be used for judging merit or worth, improving decision making, or serving accountability needs. The information of interest in the present instance is primarily for accountability purposes. What information is available or can be obtained that bears upon the accountability of NSF to the public for its curriculum development activity?

Impact is defined in the sense of effect, that is, the force of impression or operation of one thing on another. In this instance, the stimulus is provided by the National Science Foundation, while the potential responder is the educational system in general and the field of science education in particular. Synonyms for the word impact as it is used here include effect, consequence, result, or outcome, with each word referring to a looser or remoter connection to a known and immediate cause.

National curriculum projects are those multi-faceted, multi-year curriculum development groups that have received National Science Foundation support. Science, mathematics, and social science projects are included at both the elementary and secondary levels.

Direct Effects

Extent of Activity

An appropriate question to consider is the potential for impact based on the extent of NSF involvement in curriculum development. During the first 11 years (1956-1967) of the Course Content Improvement Program (now called Materials and Instruction Development Section, MIDS), more than 100 million dollars was used to support major curriculum projects.²

Estimates of support the past eight years are approximately 65 million dollars, giving a grand total of about 165 million dollars for the 19 years of the program. While this figure may appear small compared to government cost overruns on some military equipment, it does represent a substantial input into the science curriculum research and development effort.

Further evidence of impact potential is available in the Eighth Report of the International Clearinghouse on Science and Mathematics Curricular Developments.³ No fewer than 141 projects in the United States are listed, representing a real proliferation of development activity in science, mathematics, and social studies. Furthermore, 47 of these projects list the National Science Foundation as a source of financial support.

In 1972, NSF was listing 26 principal curriculum study groups under their support. A recent booklet provides an up-to-date summary of the scope of NSF supported curriculum development.⁴ A total of 64 separate Course and Curriculum Improvement Projects are listed together with more than a score of related projects, conferences, and research studies.

Because a typical project may involve more than two dozen scientists and science educators, as well as a hundred science teachers, the commitment is enormous. Perhaps 5,000 professionals have in one way or another been touched by the brush of curriculum development during the past two decades.

By any standard--financial, number of projects, or professional involvement--the investment is extensive. Surely, the potential for impact does exist.

Curriculum Usage

A major criterion for assessing effect is the degree to which the new courses are accepted and used in the schools. This issue was examined in some detail in a paper entitled, "The Impact of National Curriculum Projects, the Need for Accurate Assessment."⁵ At that time I stated:

This approach has the strong appeal of simplicity and practicality. Admittedly, assessing the impact of a new program by counting the number of students using the materials is not a basis for final judgment of success. This criterion ignores the quality dimension, and probably is a function of propaganda and advertising. But a complete appraisal of the impact of these programs is impossible without it.

However, an examination of the enrollment data for PSSC as a case study in 1968 revealed a number of discrepancies in reported usage figures. I concluded:

...the available information on the acceptance of the PSSC physics course is incomplete; figures are contradictory and without sound statistical basis. A similar situation appears to exist with other course content improvement projects.

A major problem with the 1968 situation was that estimates of use came from the projects and are based on sales reports and similar data. These figures suffer validity problems because of unknown numbers of examination copies, single copies sold, tests reused, and those used by more than one class.

Two independent surveys have been conducted since that time. The National Center for Educational Statistics conducted a study on curricular practices in 1972-73. To date (1975) the results have not been published. Unfortunately, except for BSCS biology, the survey questionnaire is not very specific in identifying NSF supported projects and, in the minds of many, the results will be questionable.

A study carried out at Ohio State University in 1970-71^{6,7} is probably the most accurate determination of curriculum usage we have to date. Although the data are now five years old, a fairly good estimate of numbers of students exposed to the materials can be derived from this study. These estimates are found in Table 1.

[Insert Table 1 about here]

Course enrollment figures are from an Office of Education report for 1970-71.⁸ Numbers of students were calculated by multiplying these figures by the percentages reported by the Ohio State group. Thus, we can be very confident that more than five million children per year are studying science using NSF supported curricula. (Note this does not include math, social science, or the newer NSF curricula. To my knowledge, only NSF has estimates of these data, again based on project sales reports.)

Some idea of the discrepancy between survey data and project reported data can be obtained by comparing the Ohio data with unpublished NSF data. While a few figures are about the same (BSCS and IPS), a factor of two discrepancy appears for several projects (CBA, ESCP, and Elementary Science). It is doubtful this difference is due to the one year lag in the two sets of figures.

The implications of Table 1 are twofold. First, a great many students are using NSF supported curricula to learn their science. Second, there is a need to improve our monitoring of curriculum usage. A recommendation I made in 1968 seems even more important today:

TABLE 1
Curriculum Usage
Selected NSF Supported Projects
1970-71

<u>Subject</u>	<u>Course Enrollment</u>	<u>NSF Course</u>	<u>% Students Using</u>	<u>Number Using</u>	<u>NSF Estimates (71-72)</u>
Physics	610,000	PSSC	28	171,000	235,000
		HPP	11	67,000	NA
Chemistry	1,112,000	CHEM	28	311,000	505,000
		CBA	2	22,000	35-50,000
Biology	2,729,000	BSCS	44	1,200,000	1,300,000
Earth Sci.	1,101,000	ESCP	25	275,000	600,000
Physical Sci.	1,187,000	IPS	40	475,000	450,000
Elem. Sci.	28,000,000 [#]	S-APA	8 [*]		2,750,000
		ESS	5 [*]		3,500,000
		SCIS	3 [*]		600,000
		Other	4 [*]		47,000 ^{***}
			11.5 ^{**}	3,220,000	6,897,000
			Total	5,521,000	

[#] K-6 enrollment

^{*} % of schools; average use per grade

^{**} Midpoint of estimated range of 10-13%

^{***} MACOS

The situation suggests the need for an accurate national sampling of enrollments in science courses. A group directly concerned with this problem could not only carry out systematic surveys of enrollment, but also study the general questions of evaluation mentioned earlier. An agency concerned with many aspects of assessment, but not connected with curriculum development, would be in a position to provide descriptions of the many new projects that are evolving and to carry out investigations of specific claims made by these projects. School personnel, foundations, and the public have the right to information useful in sorting fact from speculation, innovation from repetition, and improvement from mere change.

Achievement of Program Goals and Objectives

Another way to assess impact is to provide evidence that the goals of the course and curriculum improvement program have been achieved. This approach currently suffers from the lack of clear statements of goals and the lack of available evidence relating to these goals. In 1966, the NSF goal was stated as, "The prime objective has been to encourage the development of improved teaching materials in mathematics, science, and engineering through the collaboration of scientists, teachers, and educators."⁹

Although the recent (1974) publication summarizing course improvement activity does not speak to goals, other NSF documents hint at general purposes. In a statement before a House subcommittee on science, research, and development, March 7, 1973, the development of educational materials was deemed important for the improvement of education for careers in science and the development of science literacy. To my knowledge, no systematic study of success in achieving these general goals has been planned. However, it would appear that any attempt to assess impact must include evidence that the program is accomplishing its objectives. Such a study is not only feasible, it seems highly desirable at the present time.

Project Evaluation Results

Summative evaluation provides information about the outcomes of a course or curriculum. Such knowledge permits decisions by teachers, administrators, and legislators concerning adoption, impact on children, and prudent use of tax dollars. Certainly, summative evaluation is a key ingredient in assessing the impact of NSF supported curricula.

Unfortunately, this information is not available. In 1969, only 8 of 46 projects reported carrying out summative evaluative research.¹⁰ Only four of these projects were known to randomly assign subjects to treatment and, thus, were true experiments. If we accept Campbell and Stanley's¹¹ claim that true experiments are the only means of settling disputes regarding educational practice and the only way of verifying educational improvement, then in 1968 we had very little evidence of the impact of national projects.

To test a more recent evaluation situation, the International Clearinghouse Report¹² was examined. Of the 47 projects which reported receiving NSF support, 18 indicated they had evaluated the effectiveness of their materials. Because different questions were asked about evaluation efforts, exact comparisons cannot be made to the 1968 data. However, disregarding the seven studies in which a single doctoral thesis comprised the evaluation report, and judging the extent of evaluation by the published information available, only nine projects appeared to have useful evaluation plans. (Useful evaluations are those which yield information to assist a variety of decision makers--teachers, NSF, Congress.) Thus, it would appear that development projects have little interest in conducting evaluations of their own products.

Some notable exceptions include Project Physics and PSNS where the impact of these courses on children is quite well known.^{13,14} Other projects which have generated internal summative evaluation results include the High School Geography Project, Science-A Process Approach, BSCS, CHEM Study, Minnemast, School Mathematics Study Group, and Secondary School Mathematics Curriculum Improvement Study. Although this effort is to be lauded, it is a small fraction of the more than threescore projects supported by NSF.

An ERIC Search of NSF supported curriculum evaluation yielded 33 studies. This number is about two percent of the total number of evaluation studies listed. However, this is less than the actual number of evaluations of NSF supported curricula because the NSF descriptor is not used often by the ERIC abstractors. Other means were sought to determine the extent of project evaluation.

Reviews of research were prepared for 1970, 1971, and 1972 by Trowbridge,¹⁵ Anderson,¹⁶ and Novak,¹⁷ respectively. These reviews were examined for an assessment of curriculum evaluation activity on the part of individual researchers.

During 1970, Trowbridge reported 67 studies dealt with some aspect of national curriculum projects--nearly one-sixth of the total research output in science education. A total of 24 of these were reports of evaluations of NSF supported curricula. In terms of magnitude of impact, the potential is great. Trowbridge finds encouraging evidence at the elementary level and concludes, "...elementary science teaching is changing through the impact of the varied curriculum projects..." (p.20). He is less enthused about the impact at secondary levels and writes,

"Most of the studies relating to curriculum dealt with a review of the older curriculum projects. Very little effort was made to design new and alternative suggestions" (p.48). Furthermore, he calls for the improvement of evaluation methodology at all levels.

Anderson reviewed 375 studies produced during the 1971 year. Sixty-two of these dealt with evaluation. About a third of these (20) were evaluations of NSF supported curricula. However, Anderson concluded, "A fairly extensive collection of evaluation studies has been reported... Overall this is not a particularly fruitful group of studies when compared to other categories of studies included in this review" (p.10). Also, "there is more room for improvement in the area of evaluation studies than in many other categories which are included in their review" (p.12).

Finally, Novak reviewed 440 entries in the ERIC system pertaining to science education which were published in 1972. About ten percent of these studies specifically indicated some consideration of national curriculum projects. An examination of titles reviewed by Novak indicated 24 studies dealt directly with evaluation of national curriculum projects. Novak, in commenting on the curriculum studies he reviewed, concluded, "...most curriculum development and curriculum research continues to be based on the intention or bias of writers, for better or worse" (p.29).

Thus, we are faced with the following facts. For the three-year period under consideration, 1,218 studies in science education are stored in the ERIC files. About 150 studies (13%) were concerned with some aspect of the NSF supported curricula, while 68 of these (less than 6%) focused on NSF curriculum evaluation.

Individual researchers have not found curriculum evaluation a particularly attractive area of study and, according to the reviewers, the research that has been carried out has not provided the information needed for judicious decision making and program accountability. In view of the present situation, it seems reasonable to recommend a course of action that thoroughly summarizes the findings of the research carried out to date and, concurrently, to launch a program of curriculum evaluation that will yield the information so badly needed by curriculum consumers, developers, and funding agencies.

Secondary Effects

In addition to the direct measures of impact mentioned above, there are a number of likely secondary effects due to national curriculum projects. Secondary effects are changes in the science education system which are consequences of the curriculum improvement effort. Little evaluative evidence is currently available on these indirect outcomes, but the potential impact is large. Below are listed a number of probable secondary effects that are likely areas for further study.

Commercial Science Tests

Although in many fields the "old" standby texts will dominate the market, recent revisions reflect changes in content, style, methodology, and philosophy. It would be interesting to compare text changes in science during the decade of the '50's with changes that may have occurred from 1965 to the present. Perhaps an examination of text revisions in a non-science area, e.g., English or history, would provide a useful base for assessing the impact in science.

Another change is the decision of publishers to involve groups of scientists and educators in their development work, to trial test their materials, and to revise accordingly. Many of the newer commercial texts are using the development models followed by the NSF supported groups.

Tests and Measurement

The new curricula have probably forced changes in most of the standard tests used in science and mathematics education--for example, subject matter tests such as the Scholastic Aptitude Tests (SAT), New York Regents exams, and National Assessment tests. In addition, a variety of new tests have been created by such groups as BSCS, PSSC, CHEM, AND HPP. There is probably influence on the widely used STEP, Iowa, Dunning, and Stanford tests, but documentation of the nature of this effect, as yet, is not readily available.

Laboratory and Demonstration Equipment

One overriding characteristic of the new programs is the development of new equipment for use in the science laboratory. This equipment has been adopted and adapted by most private firms; yet, the NSF flavor is evident. Quantification of this influence may provide valuable impact information.

Teacher Training

To what extent have the national curriculum projects fostered changes in the content and process of training science teachers? Probably the influence is great; yet, no careful study of this effect has been carried out.

Present and Past Project Staffs

With more than six dozen projects funded, the number of teachers and professors working on these projects must number above 5,000. These people have been influenced by their work on the projects and have spread this

influence to their new jobs. Communication networks have been established, scientists have become educators, teachers and professors have communicated, and vast comradeships have evolved focused about a single new alphabet program.

The personal mobility of project staffs and the influence on their professional development is a potentially rich field for further study.

Teachers and Teaching Methodology

The influence that curriculum materials have had on teachers and teaching is a possible area for detecting secondary effects. An examination of the newer teacher manuals, course syllabi, lesson plans, and classroom management may reveal significant differences when compared to those of two decades ago.

Summary and Recommendations

In this paper I have reviewed the potential evidence related to the direct effects of the national curriculum projects. There is some encouraging but unsubstantiated data on curriculum usage. A few independent studies have been directed at evaluating the various programs. While the results of these studies are generally positive, the number of studies is small and methodological problems are numerous.

For the most part, the projects have not shown much interest in internal evaluations, and little evidence is available regarding the impact of the new curricula on children. Until recently, there has been little interest on the part of the Foundation to conduct comprehensive evaluations of its own goals and objects.

The problem appears to be a failure to give the same degree of systematic attention to evaluation and dissemination that has been given to curriculum development. When effects due to the projects have been sought, they have been found. Furthermore, there appears to be general consensus that the Program has greatly influenced our science education system. What is lacking is a serious attempt to document this influence.

However, some recent activity suggests an emerging awareness of this problem. The newly formed Experimental Program and Problem Assessment group at NSF is very much concerned with a range of evaluation projects. An external evaluation group at the University of Minnesota (Minnesota Research and Evaluation Project) is under an NSF grant to study a variety of evaluation and dissemination problems. Chief among these is persistence of innovation, cost analysis, evaluation guidelines for project directors, as well as a five year national plan of implementation project evaluation.

Some of the more recent projects, e.g., USMES, use an external evaluator concurrently with program development--and the work of monitoring curriculum usage at Ohio State University has already been mentioned.

A model for evaluation that the Foundation recently has used provided for an external evaluation team to study the impact of the multimillion dollar Systems Projects. What NSF learns from this study and others will be valuable information for future decision making.

If studies such as these continue to be funded and if interest and support is found for the several evaluation needs discussed in this paper, we have taken a giant step to document the impact of this major curriculum reform effort. Legislators, teachers, administrators, students, and parents have the right to expect this documentation.

References

1. News and Comment, Science 189(4196): 26-28, July 4, 1975.
2. Welch, W.W., "The Impact of National Curriculum Projects, The Need For Accurate Assessment," School Science and Mathematics 68(3): 225-234, March 1968.
3. Lockard, J. David, "Eighth Report of the International Clearinghouse on Science and Mathematics Curricular Developments 1972," Science Teaching Center, University of Maryland, College Park, 1972.
4. National Science Foundation, "Course and Curriculum Improvement Projects," Publication No. E 74-30, Washington, D.C., June 1974.
5. Welch, op.cit.
6. Schlessinger, Fred R., et al., "A Survey of Science Teaching in Public Schools of the United States (1971) Volume I - Secondary Schools," ERIC Information Analysis Center, The Ohio State University, Columbus, 1973.
7. Helgeson, Stanley L., et al., "A Survey of Science Teaching in Public Schools of the United States (1971) Volume III - Elementary Schools," ERIC Information Analysis Center, The Ohio State University, Columbus, 1973.
8. National Center for Educational Statistics, "Patterns of Course Offerings and Enrollments in Public Secondary Schools, 1970-71," HEW Publication No. (OE)73-11400, U.S. Government Printing Office, Washington, D.C., 1972.
9. Clark, George M. (ed.), "The Course Content Improvement Programs of the NSF," Staff, Division of Pre-College Education in Science, in the BSCS Newsletter 28: 15, Boulder, Colorado, April 1966.
10. Welch, W.W., "Curriculum Evaluation," Review of Educational Research 39(4): 429-443, October 1969.
11. Campbell, Donald T. and Stanley, Julian C., "Experimental and Quasi-Experimental Designs for Research on Teaching," Handbook of Research on Teaching (edited by N.L. Gage) Rand McNally, Chicago, 1963, pp. 171-246.
12. Lockard, op.cit.
13. Welch, W.W., "Review of the Research and Evaluation Program of Harvard Project Physics," Journal of Research in Science Teaching 10(4):365-378, 1973.
14. Welch, W.W., "Evaluation of the PSNS Course II: Results," Journal of Research in Science Teaching, 9(2):147-156, 1972.
15. Trowbridge, Leslie W., "A Summary of Research in Elementary, Secondary, and College Levels of Science Education for 1970," ERIC Information Analysis Center, The Ohio State University, Columbus, September 1972.

(cont)
References

16. Anderson, Ronald D., "Review of Research in Science Education for the Year 1971," SMEAC Report (mimeo) ERIC Information Analysis Center, The Ohio State University, Columbus, April 1973.
17. Novak, Joseph D., "A Summary of Research in Science Education - 1972," SMEAC Report (mimeo) ERIC Information Analysis Center, The Ohio State University, Columbus, December 1973.